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APPLIED MECHANICS REVIEWS

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BLADE FLUTTER IN AXIAL FLOW TURBOMACHINES

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1. FIELD OF INTEREST

DESIGN of large steam turbines has depended for many years on correct determination of natural frequencies of their blades, a problem which now is well under control. The exciting forces are directly related to the steady-state bending stresses. Experience with the turbine component in aircraft gas turbine plants has not essentially changed this situation. It is the advanced axial-flow compressor, particularly of the aircraft variety, which expands the blade vibration problems in new directions.

The first paper on self-sustained blade vibration in axial compressors was written by Shannon (18) in 1945. The subject thus gained actuality to compressor designers about fifteen years ago. It continues to be a headache.

2. PRESENT SITUATION

Neither the knowledge of the undulating aerodynamic phenomena nor the art of blade design has reached a satisfactory state. A well-rounded theoretical treatment has not been presented yet, and much conflicting experimental evidence makes a concise, logical review impossible. Therefore the following only represents an attempt to trace the most important features in this rapidly advancing branch of engineering science.

The reader is referred to an excellent survey in 1956 by Sabatiuk and Sisto (32) on aerodynamic excitation problems, where various aerodynamic sources of blade vibrations are classified. The recent report by Carter and Kilpatrick (34) including a series of clarifying communications, gives an up-to-date account of the main issues at the end of 1956. The same year, Benser and Finger (41) reported on a wide range of American aircraft engines and reached the conclusion that the phenomenon of rotating stall must be considered the main cause of blade failures.

In discussing the problem proper, one may approach the subject either from the viewpoint of blade vibration, particularly self-sustained vibration in completely uniform upstream flow, which stalls over the blades, or one may take the general unsteady aerodynamic flow as a point of departure. The situation is characteristically described in (32) with the picture of a closed control loop, embracing both aspects, whereas the authors of (41) essentially assume the aerodynamicist's attitude. It is generally recognized by now that neither aspect may be applied in extremum to the exclusion of the other.

The failure of "design rules" for blade flutter is largely a result of neglecting the over-all aerodynamics when viewing the problem as an isolated blade vibration. On the other hand, despite this criticism, the opposite attitude is no better single handed, since it fails to give any direct quantitative contribution to the design stress problem, however interesting it is to study unsteady aerodynamics as such. Thus to advance the art of mastering blade stresses one is also forced to transform the results of unsteady aerodynamics into force reactions on the blades. The eventual outcome will continue to be a certain blade design philosophy, whether it is expressed in "design rules" or assumes a more individual attitude.

As a matter of fact, Benser and Finger adequately divide unsteady compressor flows in three categories, of which only two really do indicate deteriorating over-all compressor performance. They are known as surge, involving both the compressor proper and its attached external ducting, and compressor stall, which implies a stalling and reverse flow of every single blade row. The main importance of rotating stall, on the other hand, rests with the influence on blade stresses, which really appears to be the main practical motivation for the study of the vagabonding stall cells. Since violent blade vibrations are observed in stalled flow without propagating stall cells, for example in two-dimensional cascades and also in some compressors, it is obvious that rotating stall cannot be the sole cause of blade failures.

In summing up the present state, one may say that research in the past decade has led to cognizance of self-sustained vibrations of blades operating at high angle of attack, i.e. stall flutter, and the interference of fundamental bending mode frequency with any possible number of rotating stall cells, which might be conceived of as a forced vibration phenomenon. Other sources do exist, though not to the same extent, despite they may be disastrous in the particular case.

The circumstances in multi-stage compressors may be surveyed in the mass flow-pressure ratio diagram, where (34) indicates a number of critical zones:

In fig. 1 the zones concern the following observations:

Type I:	Stalling flutter or stall cell excitation of the low-pressure stages at part speed.
Type II & III:	Choking flutter of the high-pressure stages due to choking of the whole cascade.
Type IV:	Shock stalling flutter due to instability of shock wave location on blade just above the drag critical Mach number. (Shock wave—boundary layer interaction).
Type V:	Choking flutter of the first stage.
Type VI:	Stalling flutter of stall cell excitation of the high-pressure stages.

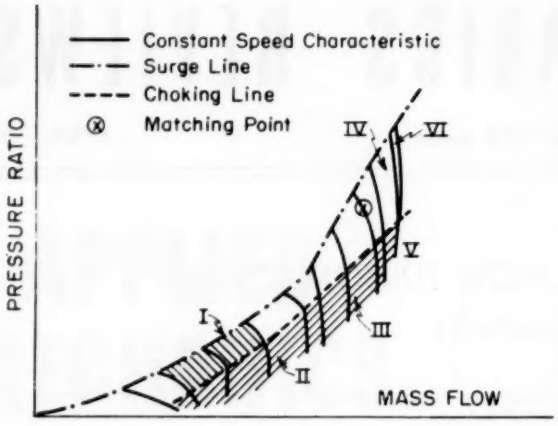

Fig. 1

No single compressor exhibits all the above excitation phenomena, fortunately.

3. AERODYNAMIC EXCITATIONS IN POTENTIAL FLOW

The aircraft wing flutter has been successfully mastered by classical aeroelastic theory, dealing with smooth flow, fulfilling the trailing-edge Kutta condition (1), (2). It is natural that application of the same general limitations has been attempted for compressor and turbine blades, even though a formally correct treatment of the cascade becomes rather involved as soon as the blades cease to be fixed relative to each other, as shown by Mendelson & Carrol (7), Sisto (8), Wang et al. (11), and Chang & Chu (12). The forces on the individual blade in a cascade, assuming fixed relative geometry within each blade row, have been studied by Kemp & Sears (9) and Woods (10).

Airplane wing flutter is usually characterized by the change of torsional and bending mode natural frequencies. Under the influence of aerodynamic reactions, these coincide into one common frequency at a discrete critical flutter velocity (1), (2).

This situation is not typical of blade flutter. Taking into account the ramifications imposed by cascading and other particulars of turbomachine blading, one may say that neither theoretically nor practically has one found potential flow excitation to be essential for the time being, though this situation may change with advances in compressor design.

One aspect of potential flow deserves attention. It concerns the various kinds of blade damping due to internal blade material, to mechanical damping in blade root fixings, and to aerodynamic forces on the blade. To blades operating in smooth flow aerodynamic damping is important. Thus upstream disturbances or gusts represent typical superimposed aerodynamic excitations, which are counteracted by aerodynamic damping forces. Theoretical work by Greenberg (5), (6) has been used by Schnittger (25) to form a first approximation to these cases.

4. AERODYNAMIC EXCITATIONS IN STALLED FLOW

The first experimental evidence was provided by Studer (13) in 1936 and concerned self-sustained pitching vibrations of a two-dimensional wing. In the next ten years, torsional vibrations continued to be the main subject and many single airfoil and cascade tests (14), (15), (18) enlarged the results of Studer and were dealt with as an anomaly of classical theory (19).

Up to this point there was no clear definition of "critical velocity." Practical compressor experience and the work of Halfman et al. (22), Sisto (23), (24), Pearson (28), (29), and Schnittger (26), (27) contributed to an understanding of the presently accepted fact that there exists no critical velocity in the classical sense. Rather, it is a matter of defining a stress level in the blade root. The velocity which, under a given set of conditions, makes the stresses reach the defined stress level, sporadically or more or less continuously, may be termed critical from a practical point of view only.

Gradually one realized that blade failures in compressors were due to bending rather than torsional vibrations. Self-sustained bending vibrations were found in two-dimensional cascades, but somewhat overlooked to begin with in face of the strong torsional vibrations, which were observed over a more extended incidence range. Today it is generally accepted that bending vibrations are the harmful ones in turbomachine blading.

About at the same time that these circumstances began to emerge, the important research on stall propagation started in the USA. Emmons group at Harvard (35) and Rannie and his colleagues at California Institute of Technology (37) and (38) simultaneously explored the features of asymmetric flow. The subject has since received much attention, and important contributions have been made by Benser et al. of NACA (36), (41), by the group at MIT Gas Turbine Laboratory (40), (42), and Sears (39). The main result of this research is that a stalled annular cascade is not usually uniformly overstaggered. Instead, it exhibits a number of stalled cells, which propagate along the cascade in peripheral direction with intervals of smooth flow between each propagating cell, the width of which may vary between a couple of blade spacings up to half the periphery. This last occurrence is the situation of "compressor stall," the second category of flow disturbances discussed above. In this case, the rotating stall limited to one or two blade rows is extended throughout the whole compressor, which contains a solid, rotating wake region.

5. THE AERODYNAMIC MECHANISM OF SELF-SUSTAINED BENDING MODE VIBRATION IN STALLED FLOW

In stalled flow the lift coefficient at high incidence will have a negative slope $\partial C_L/\partial\alpha$, fig. 3. The translational motion adds an apparent change of angle of attack $\alpha' = \dot{h}/V$, fig. 2, so that aerodynamic work is fed into the blade during a harmonic cycle of vibration in stalled flow.

One of the main issues today is the question of how this mechanism is related to the propagating stall. Carter and Kilpatrick (34) seem to prefer, for practical purposes, to regard the aerodynamic excitation as stall flutter within the stall cell together with a superimposed resonance between the stall cells and blade natural frequency. Propagating stall is known to take place also with completely rigid blades, but Sisto (34) feels that the interference between stall cell pulses and blade vibrations may establish a state which implies a mutual interaction between the over-all cascade flow and the blade vibrations. More research is necessary to understand the time relationships of stall cell motions and blade motions (in-phase and antiphase motions of adjacent blades belong in the picture).

INITIAL ANGLE OF ATTACK = α_i
APPARENT CHANGE OF ANGLE = $\alpha' = \frac{\dot{h}}{V}$
INSTANTANEOUS ANGLE OF ATTACK = $\alpha = \alpha_i - \alpha'$

Fig. 2

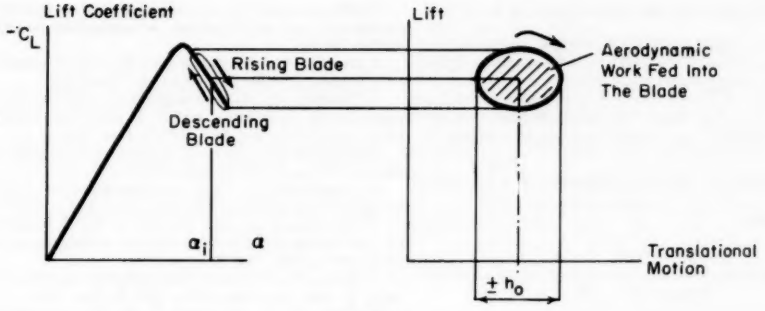

Fig. 3

6. THE STRESS PROBLEM

An elementary energy balance for the aerodynamic work described above and the energy dissipation resulting from mechanical damping is necessary in order to arrive at any quantitative conclusion. Though elementary, already this operation is a subject of controversy. Assuming that total mechanical damping is represented by the logarithmic decrement δ of the cantilever blade as measured in vacuo, one obtains for the energy dissipation per cycle

$$W_D = \omega^2 \cdot b_0^2 \cdot \delta \qquad [1]$$

ω = blade bending frequency

b_0 = blade tip amplitude

δ = total mechanical damping

The simplest assumption possible about aerodynamic work implies two main premises, namely (1) the neglect of any phase lag between velocity of blade and aerodynamic reaction in stalled flow and (2) the assumption of a linear negative slope of lift coefficient versus incidence. This means that incremental force F is

$$F = \text{const} \cdot \frac{b \cdot \rho \cdot V^2}{m} \cdot \alpha^1$$

but $$\alpha^1 = \dot{b}/V$$

thus $$F = \text{const} \cdot \frac{b \cdot \rho \cdot V}{m} \cdot \dot{b} \qquad [2]$$

where

ρ = air density

ρ_{Mtrl} = material density

m = blade weight per unit span, proportional to $b \times t \times \rho_{Mtrl}$

b = semichord

t = blade maximum thickness

$\dot{b}$ = instantaneous translational blade velocity

V = mean air velocity

Assuming harmonic vibration with

$$b = b_0 \cdot \cos \omega t$$

the aerodynamic work per cycle becomes

$$W_A = \oint F \, db$$

$$W_A = \text{const} \cdot b_0^2 \cdot \frac{\rho}{\rho_{Mtrl}} \cdot \frac{V \cdot \omega}{t} \int_0^{2\pi} \sin \tau \sin \tau \, d\tau \qquad [3]$$

$$W_A = \text{const} \cdot b_0^2 \cdot \frac{\rho}{\rho_{Mtrl}} \cdot \frac{V \cdot \omega}{t}$$

This is the form of equation derived by Pearson and Carter and Kilpatrick. It is seen that both equations [1] and [3] contain the amplitude b_0 to the square, and that from the energy balance $W_A = W_D$ one obtains a "velocity of divergence," above which amplitudes increase indefinitely to the point of destruction. This "velocity of divergence" takes the form

$$V_{crit} = \text{const} \cdot \delta \cdot t \cdot \omega \cdot \frac{\rho_{Mtrl}}{\rho} \qquad [4]$$

Sisto (24) and Schnittger (27) work with somewhat different approaches to the aerodynamic reactions. Sisto assumes that the negative slope is prevailing only over a limited range of incidence and that $C_L = f(\alpha)$ follows a smooth-changing curve. Schnittger concentrates the incremental force reaction into a jump $C_L{}^*$ in the lift coefficient. The jump is assumed to be triggered at once to the full amount, working on and off the blade at a constant magnitude, independent of the magnitude of the triggering change of angle of attack. He also takes into account phase shift between velocity of blade and occurrence of $C_L{}^*$. Both these approaches to the aerodynamic excitation problem lead to a form where aerodynamic work no longer is proportional to b_0^2 but to a function $f(b_0)$ and b_0, respectively. The practical implication is that finite, limited amplitudes are to be expected. The velocity obtained from the energy balance is no "velocity of divergence." It is rather related to a stress level.

Expounding the second method one has for the incremental force F

$$F = \text{const} \cdot \frac{b \cdot \rho \cdot V^2}{m} \cdot C_L{}^* \qquad [5]$$

The aerodynamic work is obtained as before:

$$W_A = \text{const} \cdot \frac{b_0}{t} \cdot \frac{\rho}{\rho_{Mtrl}} \cdot V^2 \cdot C_L{}^* \qquad [6]$$

Putting $W_A = W_D$ renders

$$b_0 = \text{const} \cdot \frac{\rho}{\rho_{Mtrl}} \cdot \frac{1}{\delta} \cdot \frac{1}{t} \cdot \frac{V^2}{\omega^2} \qquad [7]$$

The blade root stress σ may be taken as

$$\sigma = \text{const} \cdot \frac{b_0 \cdot t}{l^2} \cdot E \qquad [8]$$

E = Young's modulus

l = length of cantilever blade

For the natural bending frequency of the cantilever one has:

$$\omega = \text{const} \cdot \sqrt{\frac{E}{\rho_{Mtrl}}} \cdot \frac{t}{l^2} \qquad [9]$$

Inserting [7] and [9] in [8] gives the desired result for σ:

$$\sigma/\sigma_{Fatigue} = \text{const} \cdot \frac{\rho}{\rho_{Mtrl}} \cdot \frac{\sqrt{E \cdot \rho_{Mtrl}}}{\sigma_{Fatigue}} \cdot \frac{C_L^*}{\delta} \cdot \frac{V^2}{\omega \cdot t} \quad [10]$$

The ratio $\sqrt{E \cdot \rho_{Mtrl}}/\sigma_{Fatigue}$ has been shown by Pearson to be rather independent of choice of blade material. Putting $t = \left(\frac{t}{b}\right) \cdot b$ and defining the frequency parameter $k = \frac{\omega b}{V}$ one may transform Eq. [10] into

$$\sigma/\sigma_{Fatigue} = \text{const} \cdot \frac{\rho}{\rho_{Mtrl}} \cdot \frac{C_L^*}{\delta} \cdot \frac{1}{k} \cdot \frac{b}{t} \cdot V \quad [11]$$

The fact that the phase lag changes the timing of C_L^* with respect to blade velocity, introduces another k-dependent factor in Eq. [11] which more generally is written

$$\sigma/\sigma_{Fatigue} = \text{const} \cdot \frac{\rho}{\rho_{Mtrl}} \cdot \frac{1}{\delta} \cdot \frac{b}{t} \cdot F(k) \cdot V \quad [12]$$

From (34) it appears that the concept of stress level rather than "velocity of divergence" is applicable to present compressor experience.

Carter and Kilpatrick demonstrate a reasonable agreement with respect to dependence on air velocity. They report a definite rise of stresses with air density ρ, but apparently there exists no linear relationship as implied by [4] or [12]. Concerning material density ρ_{Mtrl}, Pearson states that stresses are not reduced by material density. Instead, his results indicate that the ratio $\sigma/\sigma_{Fatigue}$ remains relatively constant when exchanging blade material in an actual case. Thus, according to Pearson, ρ_{Mtrl} should not appear in [4] or [12]. Carter and Kilpatrick believe that the reason for the discrepancy with respect to ρ and ρ_{Mtrl} is partly explained by variations in mechanical damping δ, particularly the important root damping. Experimental evidence is insufficient to settle the question.

The influence of the frequency parameter k is still not wholly clarified. To assume that $F(k)$ of Eq. [12] is a constant quantity with respect to k appears to be a premature conclusion from existing experimental results.

7. CONCLUSIONS

There seems to exist general agreement on the following points:

(a) Stall flutter and stall cell excitation are responsible for the majority of compressor blade failures.

(b) The blade root stress amplitudes in bending mode stall flutter vary irregularly in time.

(c) Superimposed on the blade natural frequency is another frequency, roughly corresponding to 3 to 7 harmonic stall wave excitation. Interference has been testified by several reports.

(d) When blades are not excited by rotating stall interference, the stall flutter root stresses attain a general level of disturbance of the same order of magnitude in cascade tunnel and compressor tests. This level may be objectionable or not, depending on the actual circumstances.

(e) The most general recommendation to remedy the situation is to stiffen the blades sufficiently to build in enough mechanical or aerodynamic damping (by local variation of blade twist) or to use tip shrouding.

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Theoretical and Experimental Methods

(See also Revs. 1104, 1111, 1119, 1129, 1130, 1134, 1173, 1190, 1191, 1263, 1299, 1301, 1323, 1364, 1366, 1374, 1380, 1401)

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Reviewer considers following extract from foreword to be an excellent description of this work. "The time lag between scientific discovery and engineering application has recently been shortened so that it is more than ever necessary for the engineer to be aware of significant developments in the fields of mathematics and the physical sciences. To this end the Engineering Departments of the University of California arranged a series of lecture courses in modern physics, mathematics, and chemistry for their staffs, students, and graduates to make them aware of advances in these sciences. Each course consisted of a series of invitation lectures by teaching scientists prominent in the field". This is the mathematical series of lectures published in book form and should be of interest to all engineers particularly as a reference to indicate mathematical methods which may be of use in tackling a given problem.

Book is divided into three major sections covering (a) physical problems expressed in differential, intergral or partial differential equations, (b) programming and operational aspects and use of probabilistic methods in solving problems, and (c) computational considerations which emphasize numerical solutions. Each section consists of chapters contributed by a well-known expert in the field with a useful list of references for those interested in pursuing the subject further. In general, example problems are used to indicate the type of engineering problem which can be tackled by broad treatment, showing the scope of what is involved yet in enough detail to permit an attack to be made on specific problems with a degree of confidence.

The book is not a textbook and, though the engineer may attack his own problems, a guide in the guise of a mathematician will be almost essential if the utmost is to be extracted from the methods. The main value of the book lies in the fact that it introduces many powerful new mathematical methods to the engineer who may realize how much the modern mathematician can help him in solving his problems. At the end of the book are name and subject indexes, both of which are extensive and useful. This is a book for the engineer to read, only studying those parts which are of particular interest, and to keep handy as a reference.

The list of the nineteen chapters indicates the scope of the work: Linear and nonlinear oscillations, Equilibrium analysis, the stability theory of Poincare and Lyapunov, Exterior ballistics, Elements of the calculus of variations, Hyperbolic partial differential equations and applications, Boundary-value problems in elliptic partial differential equations, The elastostatic boundary-value problems. The theory of prediction, The theory of games, Applied mathematics in operations research, The theory of dynamic programming, Monte Carlo methods, Matrices in engineering, Functional transformations for engineering design, Conformal mapping methods, Nonlinear methods, What are relaxation methods, Methods of steep descent, High-speed computing devices and their applications.

Reviewer noticed only one printing error in the first line of page 481; for the rest, the paper is of excellent quality and the printing very clear, particularly of the figures, and the text easy to read. In short, this is an excellent book, reasonably priced, which can be recommended to engineers who have to carry out much mathematical analysis in their work.

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E. J. Scott, USA

1079. Potters, M. L., Some calculations on a parabolic differential equation with free boundary, *Math. Centrum Amsterdam, Rap.* R. 359 b, 12 pp., 1957.

Using, for purposes of this review, the language of heat conduction, author is concerned with solution of the modified heat conduction equation

$$T'' + (T/x)' = \dot{T} \qquad [1]$$

subject to the boundary conditions: at $x = 1$, $T = T_1 > 1$ is prescribed; at the melting front, $x = X(t)$, the boundary condition $T = 1$ and

$$T' + T/x = -\dot{X} \qquad [2]$$

is prescribed; for $t = 0$ an initial distribution $T(x,0)$ $(X(0) \leqslant x \leqslant 1)$ is prescribed. The problem is of significance in the theory of superconductivity. Author outlines method of solution of problem for digital computer. The range $0 \leqslant x \leqslant 1$ is subdivided into intervals $h = 1/100$, and the two equations [1] and [2] are simultaneously solved for T and t as X takes on the successive values $1, 1\text{-}h, 1\text{-}2h, \ldots$ Dependence of solution on h and the difference equation scheme is illustrated in a graph for the case $X(0) = 1$, $T_1 = 1.5$. Cases where the problem [1], [2] admits periodic solutions are also discussed.

G. Horvay, USA

1080. Veltkamp, G. W., The behavior of a solution of Helmholtz' equation near a confluence of boundary-conditions involving directional derivatives, *Math. Centrum Amsterdam. Rap.* TW 40, 29 pp., Aug. 1956.

1081. Khaskind, M. D., Three-dimensional flow around thin bodies (in Russian), *Prikl. Mat. Mekh.* **20,** 2, 203–210, Mar.–Apr. 1956.

Author considers the stationary rectilinear movement of a curved line (thin airfoil) in unlimited space, this line being located in a plane vertical to the direction of movement. The well-known potential theory provides an integral equation which determines the normal component of the local speed at the airfoil as a function of the shape of the airfoil and the distribution of its circulation.

Two examples for the application of the above integral equation, movements of an annular thin airfoil and of a rectilinear thin airfoil which is directed vertically, are considered, due consideration being given to the Froude number.

M. Strscheletzky, Germany

1082. Lauwerier, H. A., The expansion of a function into a Fourier series with prescribed phases, valid in the half-period interval, *Math. Centrum Amsterdam. Rap.* TW 33, 32 pp., Sept. 1955.

1083. Schweizer, B., On approximate eigenvalues obtained by the method of least squares, *J. Math. Phys.* **36,** 3, 284–288, Oct. 1957.

Consider the eigenvalue problem defined by a homogeneous linear differential equation with homogeneous boundary conditions. Let it be known mathematically or otherwise that the eigenvalues are real. Suppose one employs the method of least squares to find approximate eigenvalues. It is known that this procedure often leads to complex eigenvalues, and others have usually ascribed this to a low order of approximation, a poor choice of trial functions, etc. Paper shows it is the rule, rather than the exception, that the approximate eigenvalues are complex. In this event, the real parts or the moduli of the numbers so obtained are taken as approximations to the true eigenvalues.

Y. L. Luke, USA

1084. Schroder, J., The difference method in nonlinear boundary problems II (in German), *ZAMM* **36,** 11/12, 443–455, Nov./Dec. 1956.

Author estimates the errors in solving ordinary differential equations with nonlinear boundary conditions by the method of the calculus of differences. More specifically he considers equations of the form $y'' + f(x,y,y') = 0$ and $y'' + f(x,y) = 0$ with the same boundary conditions in both cases: $ay(0) - bly'(0) = A$, $cy(1) + dly'(1) = B$ with $a,b,c,d, \geq 0$ and $ac + ad + bc > 0$.

A. Devinatz, USA

1085. Lax, P. D., and Richtmyer, R. D., Survey of the stability of linear finite difference equations, *Comm. pure appl. Math.* **9,** 2, 267–293, May 1956.

Paper deals with solution of initial value problems of partial differential equations by finite difference analogs. Basic problem is that finite difference solution converges to the true solution as mesh length is reduced. Authors define concept of stability and show that under certain conditions stability is a necessary and sufficient condition for convergence. Results are applied to the one-dimensional wave equation, the parabolic diffusion equation in two dimensions, and the DuFort-Frankel equations (one-dimensional diffusion equation).

Y. L. Luke, USA

1086. Kawai, R., Graphical method for the solution of linear differential equations of the third order with variable coefficient (in German), Proc. sixth Japan nat. appl. Mech., Univ. of Kyoto, Japan, Oct. 1956, 517–520.

Extending H. W. Vogel's method, transforming differential equation in difference equation, stepwise graphical method is presented, applicable to get transient response of third-order linear systems with prescribed variable coefficients, for any initial conditions and forcing functions.

T. Takahashi, Japan

1087. Morris, G., Testing the reliability of complicated machines: A method to limit the cost of prototype trials, *Engineering* **180,** 4687, 723–726, Nov. 1955; **Improved mathematical model for prototype trials,** *Engineering* **184,** 4766, 41–45, July 1957.

Purpose of this study is to find a method by which one can separate, by statistical means, causes for break-downs which can be permanently eliminated from those which must be accepted as characteristic of the design. For this purpose, author plots a cumulative curve of break-downs against operating time and finds that this curve begins steep (indicating a high rate of break-downs), gradually flattens, and finally reaches a constant slope. He finds that the curve can be well duplicated by assuming a constant probability for all causes that can be eliminated and another, but in itself constant, probability for those which cannot be eliminated.

H. A. Einstein, USA

1088. Kloos, J., and Turner, F., The determination of a factor of safety on the basis of a single probability parameter, *SAAB Aircr. Co. Linköping, TN* 37, 13 pp., 1957.

Authors want to advocate consequent use of probability concepts in determining factors of safety in structural components. They restrict themselves to random variations in strength of material and point out possibilibies of combination with probability of loads if the latter are statistically known.

The method of fixing the factor of safety is illustrated in examples. The probability that the strength of a structural component is less than a required value, i.e. the accepted confidence level, takes the place of the usual vague concepts. The factor of safety thus becomes a quantity which depends on the knowledge of statistical characteristics of the quantity strength.

Authors show how this factor, viz., the ratio between mean strength derived from tests and the admitted load, varies from the case where much is known about the original population to the case where only a relatively small number of test results is available.

H. J. Schoemaker, Holland

1089. Klein, M. L., Williams, F. K., Morgan, H. C., Digital differential analyzers, *Instrum. and Automat.* **30,** 6, 1105–1109, June 1957.

1090. Mori, M., Sample data process control (in Japanese), *J. Japan Soc. mech. Engrs.* **60,** 465, 1112–1119, Oct. 1957.

Details of a new process controller made from 4 input side, 5 output side memory devices and 153 relays are given. Controller responses are presented by time series and actual records, emphasizing more flexible nature of sampled data system than conventional proportional plus reset plus rate controllers. Experimental step input response of closed-loop system shown ends in one sampling period without overshoot or offset.

Y. Takahashi, Japan

1091. Hage, W. T., and Hoffman, H. T., An automatic digital-data-collecting system for use in central stations, ASME Semiann. Meet., San Francisco, Calif., June 1957. Pap. 57-SA-58, 8 pp.

1092. Stern, H., General-purpose integrator for data reduction, *Instrum. and Automat.* **30,** 2, 254–255, Feb. 1957.

1093. Bedford, Gwendolyn M., Review of current machine systems for handling information, *AGARD Publications, Rep.* 46, 19 pp. + iii, Feb. 1956.

Paper reviews current mechanical systems for handling information. Criteria are determined for the assessment of systems for processing, storing and retrieving information. The principles of

various systems are explained and their advantages and disadvantages are discussed in relation to these criteria. Finally, conclusions are drawn with reference to the feasibility of the systems reviewed for the particular project under consideration.

From author's summary

1094. Kuipers, J. W., Needed research for machine information systems, *AGARD Publications, Rep.* 47, 20 pp. + iv, Feb. 1956.

Report explains the difficulties which have arisen in using machines for documentation purposes and analyzes their causes. It emphasizes the need for research on the nature of the units to be handled in machine systems and indicates the lines along which research effort should be directed in order to overcome these difficulties. From author's summary

1095. Clapp, V. W., Operational problems requiring documentation research, *AGARD Publications, Rep.* 48, 9 pp. + iii, Feb. 1956.

1096. Taylor, D. F., On-line automatic data reduction at the Arnold Engineering Development Center, *AGARD Publications* AG18/P8, 51-73, June 1955.

1097. Lepskii, M. M., Errors in nomographic computations (in Russian), *Inzbener, Sbornik, Akad. Nauk SSSR* **22,** 223-230, 1956.

1098. Morita, K., On the high precision four variable nomographic charts of separable type, Proc. Second Japan Nat. Congr. appl. Mech. 1952; nat. Committee for theor. appl. Mech., May 1953. 299-302.

1099. Moody, W. T., Volume of intersecting cylinders, *Civ. Engng., Lond.* **61,** 604, 1121-1122, Oct. 1956.

1100. Felstein, M., How to draw and solve with spherical diagrams, *Amer. math. Monthly* **62,** 9, 631-635, Nov. 1955.

Mechanics (Dynamics, Statics, Kinematics)

1101. Fried, B. D., On the powered flight trajectory of an earth satellite, *Jet Propulsion* **27,** 6, 641-643, June 1957.

Paper deals with the problem of finding the powered flight trajectory which will result in maximum satellite altitude for a missile whose thrust magnitude and mass are specified, albeit arbitrary, functions of time, $F(t)$ and $M(t)$. The missile is considered as a point mass and the earth as a nonrotating sphere. Assuming that aerodynamic effects, dependence of thrust on altitude, and variation of gravity during powered flight could be neglected, it is found that the thrust attitude angle (with the horizontal) $\psi(t)$ should vary with the time according to $\tan \psi = a - bt$ during that portion of the powered flight where these assumptions are justified. To evaluate the constants a, b, this relation is to be used for the calculation of the burnout velocity. Their values, depending on the particular form of the functions $F(t)$ and $M(t)$, could be obtained analytically in the particular case where $F(t)$ and $M(t)$ are piecewise constant functions.

The results of this paper represent a physically reasonable program, especially when a "gravity turn" is used until the missile is high enough to justify the neglect of aerodynamic forces.

J. Beranek, Czechoslovakia

1102. Adams, E., Contribution to the problem of fastest air connection between two points (in German), *Z. Flugwiss.* **5,** 1, 12-15, Jan. 1957.

Regarding the cruise at constant height in a plane, a handy graphical method of approximation is available for plotting the route for the flight of shortest duration between two arbitrary points at any distribution of wind. The first section of the paper shows the applicability of the method of approximation to the spherical surface. The second section deals with the construction of spherical minima in Mercator mapping by means of a linear scale, depending on geographical latitude only.

From author's summary

1103. Hess, J. L., Studies on the acceleration of a body from rest. Part I, The approximate constancy of velocities produced by time-dependent accelerations having equal maximums and operating over equal distances, *Douglas Aircr. Co. Rep.* ES 26463, 22 pp., Nov. 1956.

By analytical calculations for two representative classes of accelerations, by a discussion of the reasonableness of the conclusions for more general accelerations, and by consideration of experimental data, it is shown that, if a body is accelerated from rest through a fixed distance by accelerations having the same maximum value, the final velocities will differ by very little, regardless of the shape of the acceleration-versus-time-curve. Conclusions with regard to ejection seat design are drawn from this fact. The result, however, has more general applicability.

From author's summary

1104. Westfold, K. C., The solution of linear vector differential equations containing gyroscopic terms, *Amer. math. Monthly* **64,** 3. 174-180, Mar. 1957.

A solution is given of vector differential equations of the type governing the motion of Foucault's pendulum; the method, though related to Milne's "Vectorial Mechanics," is more systematical however. Use is made of the theory of characteristic vectors: there are three distinct eigenvalues, two of which are complex.

O. Bottema, Holland

1105. Ishlinskiĭ, A. Yu, Relative equilibrium of a physical pendulum with a movable point of suspension (in Russian), *Prikl. Mat. Mekh.* **20,** 3, 297-308, May-June 1956.

Author gives some solutions of problems in theoretical mechanics on the relative equilibrium of rigid bodies with one point of support which is fixed to a movable base. For the rigorous solution of these problems it is necessary to establish definitely the initial conditions and to clearly point out the system of coordinates with respect to which the condition of equilibrium is established or to determine the forces of inertia of the motion of the elements of the rigid body. M. Maletz, USA

1106. Razumikhin, B. S., On stability of unsteady motions (in Russian), *Prikl. Mat. Mekh.* **20,** 2, 266-270, Mar.-Apr. 1956.

Generalizing certain results of N. G. Chetaev [title source **9,** 3, 193-196, 1945 and **12,** 1, 101-102, 1948], author proves the following. The unperturbed motion is stable if (1) the coefficients in the equations for the perturbations together with their first-order derivatives are bounded and satisfy the Routh-Hurwitz conditions, for every $t > 0$, and (2) there exists a finite upper limit of the integral $\int_0^t \bar{\lambda}_n(t)\,dt$ $(0 < t < \infty)$, where $\bar{\lambda}_n$ denotes the greatest root of the equation $\det(d\alpha_{ij}/dt - \alpha_{ij}\lambda - \delta_{ij}) = 0$ $(i, j = 1, \ldots, n)$, and the α_{ij} are the coefficients of a certain positive definite quadratic form. E. Leimanis, Canada

1107. Shulgin, N. V., An analysis of the motion of nonholonomial mechanical systems by a method of redundant coordinates (in Russian), *Trudi Sredneaz. in-ta* no. 37, 49-58, 1954; *Ref. Zh. Mekh.* no. 11, 1956, Rev. 7161.

By adding to the existing coordinates an equal number of additional (redundant) coordinates, author reduces a system of the

form

$$\ddot{q}_k = f_k(t, q_1, \ldots, \dot{q}_n, q_1, \ldots, q_n) \quad (k = 1,2, \ldots, n),$$

to the form of Lagrange equations of the second kind. A Liouville type of expansion is applied; the efficacy of this step is doubtful. Author applies this expansion to nonholonomial systems, introducing the conception of a "holonomizing kinetic potential"; the result is a Lagrange system with twice the number of unknowns. The case is examined of the presence of cyclic coordinates as well as the familiar example of S. A. Chapligin (the calculations are not given in complete form, which prevents correlation with existing known solutions). Having regard to the doubling of the order of the system, arbitrary redundant constants are obtained during integration, the significance of which is unexplained.

I. S. Arzhanykh

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

1108. Pozharitskii, G. K., Unsteady motion of conservative holonomic systems (in Russian), *Prikl. Mat. Mekh.* **20**, 3, 429–433, May-June 1956.

Author treats motion of holonomic systems with constraints which are independent of time. For the motion of such systems, criteria of instability are given. The derivation of the instability is made on the basis of the theory of instability by Lyapunov and Tchetayeff.

M. Maletz, USA

1109. Chetaev, N. G., Certain problems in mechanics for the stability of motion (in Russian), *Prikl. Mat. Mekh.* **20**, 3, 309–314, May-June 1956.

Author touches on examples of interest in stability problems encountered in theoretical mechanics. The general problem on stability of mechanical systems with a finite degree of freedom was first formulated by Lyapunov. The interesting feature of Lyapunov's theory is its generality wide enough to cover all problems on stability and narrowed down to embrace all possible problems on stability of motion. Lyapunov starts from Lagrange equations. In many problems, for the sake of convenience in calculations or the absence of any other means, it is necessary to use equations of motions such as Lagrange or Routh multipliers, or Poincare's, or any equations of nonholonomic mechanical systems. Strictly speaking, the equations for the constraints should be invariant, and the problems of stability get thus the character of conditional stability since the initial values of the dependent variables and their velocities are limited by the equations of constraints.

Author then considers the problem of three bodies, the case of gyroscopic stability, and the problem of Cauchy on the development of the Hamilton analogy between dynamic conservative holonomic mechanical systems and the optics of Huygens.

M. Maletz, USA

1110. Tobilov, T. A., The steady motion of a bogie truck on a railway track (in Russian), *Izv. Akad. Nauk SSSR, Otd. tekh. Nauk* no. 10, 157–160, 1955; *Ref. Zh. Mekh.* no. 11, 1956, Rev. 7218.

The steady running of a vehicle of the nature of a bogie truck on a railway track is investigated for the case of rectilinear motion at constant speed. Applying the theorem of Hermite-Biller and making certain assumptions, author comes to the conclusion that the motion of a truck of this kind cannot be asymptotically stabilized.

B. S. Razumikhin

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

1111. Gredeskul, A. B., A method of analytical integration of the differential equation of motion of a motor vehicle (in Russian), *Trudi Khark. avtom.-dor. in-ta* no. 16, 7–16, 1955; *Ref. Zh. Mekh.* no. 11, 1956, Rev. 7169.

The tractive effort on the driving wheels during the interval of acceleration between maximum and critical speed is expressed by the relationship $P = A - BV^2$; and the resistance to motion by the expression $R = C + DV^2$. Author then reduces the equation of motion of the motor vehicle to the form $V' = a + bV^2$, in which a and b are constants for each gear speed and condition of motion. The solutions obtained are analyzed for particular cases; author indicates that these results have been confirmed experimentally.

K. S. Kolesnikov

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy of Ministry of Supply, England

1112. Tishchenko, O. F., A graphical-analytical method of investigating horological toothed gears (in Russian), Interchangeability and Metrology in Mechanical Engineering, Moscow, Mashgiz, 1955, 25–35; *Ref. Zh. Mekh.*, 11, 1956, Rev. 7235.

The characteristics of horological toothed gears are briefly considered and a graphical method of analysis described.

An instrument is also described which enables the pitch line of a conjugate pair of wheels and pinions to be traced and the entry and exit angles of the teeth determined.

The conception is introduced of a dynamic pole of contact, determining the transmission ratio of the turning moments between wheel and pinion.

A. M. Shekhtman

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

1113. Partensky, B. M., Cumulative error in the toothed gears of a kinematic linkage (in Russian), *Trudi in-ta mashinoved. Akad. Nauk SSSR* no. 8, 18–25, 1955; *Ref. Zh. Mekh.* no. 11, 1956, Rev. 7238.

The problem is examined of determining the positional error (setting error) in the intermediate gears of a multistage gear train with reference to the setting of the drive pinion, assumed to be ideally accurate.

A. D. Nevskii

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

1114. Fisher, F. G., and Allen, R. K., Investigation of causes of low wheel-to-rail adhesion and possible methods of improving it, *Trans. ASME* **79**, 2, 377–388, Feb. 1957.

Wheel-to-rail adhesion is fundamental to the operation of a railroad. The potentially high tractive effort of modern diesel-electric and electric locomotives has focused attention more sharply on conditions which limit adhesion. Train stalls, rail burns, flat wheels, and damaged electric traction equipment all point to the importance of the problem. Extensive tests have yielded much information on the causes of low adhesion and methods of improving it. The results indicate that running adhesions in excess of 26% can be maintained by the application of certain materials to locomotive drivers or to the rail.

From authors' summary

1115. Desoyer, K., Rolling friction between disks with different elasticity constants (in German), *Öst. Ing.-Arch.* **11**, 2, 146–160, Apr. 1957.

On the supposition that Coulomb's laws of friction are valid for slipping, the problem of rolling friction between cylindrical bodies with different elasticity contants is solved by means of singular integral equations determining the total load and the shear stress distribution in area of contact. In the limit cases of complete sliding and of complete slipping these equations give a solution in closed form. It is shown that in the general case the system of

equations can be solved if an auxiliary function is introduced which is determined by a singular integral equation.

The paper is based on Föppl's theory of rolling friction and generalizes the result of Heinrich's article in title source **4**, p. 363, 1950; AMR **4**, Rev. 1909. Z. Horak, Czechoslovakia

1116. Owen, T. B., Low speed static and fluctuating pressure distributions on a cylindrical body with a square flat plate air-brake, *Aero. Res. Counc. Lond. curr. Pap.* 288, 10 pp. + 7 figs., 1956.

There is a very rapid increase both in the r.m.s. amplitude of the pressure fluctuations and in the area of the body affected, if the brake angle is increased beyond 50°. At the lower frequencies there is a large increase in amplitude between 40° and 50° which is associated with the appearance of a regular shedding of turbulent eddies. On the model used, with an average gap of about 27% of the length of the side of the brake, the shedding frequencies are in close agreement with those measured on an isolated plate at the smaller brake angles and slightly higher than on an isolated plate at the higher brake angles. The fluctuating pressures due to the brake are little affected by the distance of the brake from the tail of the body. From author's summary

1117. Bradbury, F. J., and Parnell, F. G., Disk brakes for motor vehicles, *Instn. mech. Engrs. Proc. Auto. Div.* no. 1, 48 pp., 1955–1956.

The development of disk brakes is reviewed from the early part of the twentieth century to the present time. A number of designs are discussed and the characteristics of disk brakes are compared with those of drum brakes. In particular it is shown that the outstanding feature of the disk brake is its anti-fade characteristic which gives it superiority over the drum brake in installations where space is restricted.

The main part of the paper is devoted to a consideration of those factors which control design, and it is shown that rigidity is of paramount importance if a disk brake is to be used without an external servo. Methods of obtaining the required degree of stiffness are discussed and curves are drawn to show the influence of caliper stiffness and other lost motions on displacement ratio and brake pedal travel.

The application of disk brakes to commercial vehicles is discussed and details are given of an installation on a passenger service vehicle. Consideration is also given to the hand-operated disk brake on the transmission of commercial vehicles, and the paper outlines why this arrangement may become more general when disk brakes are used on the road wheels. Friction pad characteristics are discussed in relation to rate of wear and recommended horsepower absorptions.

There are many problems associated with the installation and protection of disk brakes and these are outlined with emphasis on the need for attention to caliper position and wheel-bearing design. It is also suggested that although the exposed disk brake has given satisfactory results it may become necessary to shield the disk, which would result in either poorer cooling or complex ducting. From authors' summary

Servomechanisms, Governors, Gyroscopics

(See Revs. 1078, 1086, 1256, 1297)

Vibrations, Balancing

(See also Revs. 1131, 1164, 1165, 1414)

1118. Miesse, C. C., The free vibration of a variable mass, *Jet Propulsion* **27**, 10, 1103–1104, Oct. 1957.

Author develops equations of motion for linearly damped simple system in which mass varies linearly with time. Frequency of this system turns out to be product of the frequency of the simple harmonic system with the instantaneous mass and a correction factor which appears small in most practical cases. Amplitude of oscillation is a function of the damping and the rate of change of mass.

While author thinks of application to a draining tank, he does not consider the independent motion of the liquid relative to the tank. E. G. Chilton, USA

1119. Ergion, E. I., Transient response of a nonlinear system by a bilinear approximation method, *J. appl. Mech.* **23**, 4, 635–641, Dec. 1956.

Author discusses in detail the effects of the (principally well-known) method of approximating a curved characteristic line of an oscillatory system (having one degree of freedom) by two straight line segments. As a criterion for best approximation, minimizing of the mean square error is used. Examples are given which show the feasibility of the procedure.

K. Klotter, USA

1120. Vodicka, V., Bending vibration of composite rods (in German), *ZAMM* **37**, 1/2, 44–51, Jan./Feb. 1957.

The general solution is presented for a straight rod with a constant cross section, consisting of various lengths with different densities. The method of solution, found by means of Laplace transforms, is given. It is shown that even with only two different lengths the amount of computational labor is almost prohibitive. M. Botman, Canada

1121. Godzevich, I. N., The determination of the natural frequency of oscillations of straight linear bars of variable sections with distributed and concentrated mass (in Russian), *Trudl Ural'sk. politekh. in-ta Sb.* 54, 126–132, 1955; *Ref. Zh. Mekh.* 1956, Rev. 6191.

The small oscillations of a thin weighted bar are examined by means of integral equations. For the very lowest frequency of natural oscillations a two-sided evaluation is made, agreeing with the results obtained by S. A. Bernstein ["A new method for determining the frequency of oscillation of elastic systems," VIA RKKA, 1939] and the unpublished results of L. K. Narets, referred to by the author. An example is examined of the determination of the very lowest frequency of transverse oscillations of a shaft of variable cross section, carrying a concentrated mass.

A. I. Oseledko

Courtesy Referativnyi Zhurnal, USSR

Translation, courtesy Ministry of Supply, England

1122. Babaev, N. N., The transverse vibrations of a bar of variable cross section in the presence of shearing deformation and internal inelastic resisting forces (in Russian), *Inzhener. Sbornik, Akad. Nauk SSSR* **22**, 17–25, 1955; *Ref. Zh. Mekh. no. 11, 1956*, Rev. 7788.

In an earlier published work by the same author [cf. *Ref. Zh. Mekh.* 1955, Rev. 5176] a solution was given of the problem of the transverse vibration of a bar of variable cross section without allowing for the shearing deformation. The influence of shearing deformation, small in the case of vibrations of a frequency approaching that of the natural frequency of vibration of the bar, becomes increasingly important as the vibration frequency rises.

In the present paper, the general relationships are stated, determining the transverse vibrations of a nonprismatic bar, allowing for the shearing deformation and dissipation of energy. An example is examined of a prismatic bar with hinge-supported ends. The results show that, with a sufficiently high mode of natural vibration, decay is determined by the nonelastic resistance forces

corresponding to the relative shearing deformations of the cross sections of the bar. E. I. Silkin

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

1123. Dutta, Chinmayee, and Niyogi, S. B., The statical displacement in bowed string, *Indian J. theor. Phys.* **4,** 2, 51–56, June 1956.

Paper concerns experimental evaluation of the displacement of mean position of a violin string in the direction of motion of the bow, causing asymmetry of vibration of the string. Results obtained are held to be valid only in a small neighborhood about the bow. H. J. Weiss, USA

1124. Herrmann, G., and Mirsky, I., On vibrations of conical shells, Columbia Univ. Dept. of Civil Engng. and Engng. Mech., Inst. of Flight Structures TN 4 (CU-14-57—AF-1247-CE) 24 pp. + 8 figs., Apr. 1957.

Frequencies of truncated conical shells are determined using a Rayleigh-Ritz procedure. Sinusoidal mode shapes are assumed which satisfy the equation of motion of a corresponding cylindrical shell. The approximate values should therefore have good accuracy for small semivertical angles, or small "conicity."

It is shown that for short shells the conicity lowers the frequency somewhat, while for long shells the frequency increases appreciably with conicity. This influence is strongest if the number of circumferential waves is 3. As may be expected, the frequency of thin shells and the lowest frequency are more sensitive to changes in shape.

It is shown further that the equations of motion may be integrated in terms of known tabulated functions in several special cases. From authors' summary by J. C. Truman, USA

1125. Sittig, E., On the classification of elastic modes of an isotropic circular cylinder (in German), *Acustica* **7,** 3, 175–180, 1957.

The fundamental equations for the isotropic elastic solid in the form of an infinite circular cylinder yield, beside the simple modes of vibration (longitudinal, torsional, flexural), more complicated modes. Altogether there is a threefold band of resonances with each resonance characterized by a triplet of integral indices (n, p, q) which are related to the nodes on the cylindrical surface and can be experimentally determined.

As the boundary problem of the cylinder of finite length cannot be rigorously solved, some departure from experiment is to be anticipated. For the special case of resonances with vanishing axial components, the discrepancies can be limited by comparison with the corresponding resonances of a thin circular disk.

From author's summary by A. I. van de Vooren, Holland

1126. McGoldrick, R. T., Calculation of the response of a ship hull to a transient load by a digital process, *David W. Taylor Mod. Basin Rep.* 1119, 17 pp., Mar. 1957.

Using finite-difference method author analyzes response of a ship hull to a concentrated vertical force instantaneously applied amidships, held constant for one second, and instantaneously removed. In given equation of motion of a length element of ship, damping term (proportional to velocity) and term for rotary inertia are considered as well as deflection due to shear.

Problem was solved on Univac. For mathematical and computational details reference is made to *DTMB Rep.* 1120. Only a few salient features of Univac solution are pointed out.

The Univac supplies a printed sheet of response data for each instant after initial application of forcing function. Sheets give vertical displacement, rotation, bending moment, and shearing force. In the future there will be included also velocity, acceleration, and displacement for each station of the ship.

Full-scale experiments combined with such calculation are necessary for a realistic evaluation of the method.

E. Steneroth, Sweden

1127. Khvingiya, M. V., The oscillation of a load fixed to a conical-shaped spring (in Russian), *Trudi Gruz. politekhn. in-ta* **31,** 89–94, 1954; *Ref. Zh. Mekh.* 1956, Rev. 5728.

Examinations are made of the oscillations of a load fixed to the free end of a spring, the other end being firmly embedded.

Taken into account were the influence of mass and the moment of inertia of the spring, as the consequence of which torsional, in addition to vertical, oscillations were observed.

V. M. Ponomariv

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

1128. Shteinvol'f, L. I., Experimental arrangement for the investigation of torsional oscillations (in Russian), *Trudi Khar'kovsk. politekh. in-ta* **5,** 129–136, 1955; *Ref. Zh. Mekh.* 1956, Rev. 6202.

A description is given of the experimental arrangement for the investigation of torsional oscillations of a multi-mass system, in which the excitation and character of the torsional oscillations are similar to the excitation and character of oscillations in the crankshafts of engines.

As an inert exciting agent in the rotating system of the arrangement, a planetary mechanism with unequally suspended loading on the cogwheels is adapted.

In the arrangement an advance examination was made on the addition of antivibrators and dampers for the investigation of torsional oscillations of multi-mass systems with nonlinear elements. A. F. Rozhnyatovskii

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Translation, courtesy Ministry of Supply, England

Wave Motion in Solids, Impact

(See also Revs. 1125, 1163, 1164, 1165)

1129. Miklowitz, J., The propagation of compressional waves in a dispersive elastic rod Part I—Results from the theory, *J. appl. Mech.* **24,** 2, 231–239, June 1957.

The propagation of a pulse of stress waves in a cylindrical bar is an example of pulse propagation in a dispersive medium which, at first sight, appears to be plain sailing. In point of fact, it has proved impossible to obtain the exact solution of the problem based on the general equations of motion of an elastic solid in cylindrical coordinates (the Pochhammer-Chree equations), subject to relevant boundary and initial conditions. It is for this reason that so much attention has been devoted in recent years to solutions based on less exact equations of motion.

The paper under review is a substantial contribution to the subject and it attacks the problem of the propagation of compressional pulses from the standpoint of the equations derived by Mindlin and Herrmann [AMR **5**, Rev. 1308]. It may be regarded as a continuation of a previous paper [AMR **9**, Rev. 670], in which the author derived, by Laplace transform techniques, the solution for a semi-infinite cylindrical rod, with its axis lying along Ox, where the accessible end $(x = 0)$ is constrained radially and is subjected to a uniform longitudinal stress which is a step-function as regards time t. The solutions contained improper integrals arising from the inversion of the Laplace transforms. In the present paper, these integrals, which are difficult to compute, have been evaluated numerically with a high-speed electronic computer. The results are presented in the form of curves showing (1) the relationships between the longitudinal stress in the bar and t, for various

values of x, (2) the effects of varying the values of Poisson's ratio and the correction factor κ_1 of the Mindlin-Herrmann theory on these relationships, and (3) the effect of the variation of κ_1 on the phase and group velocity dispersion curves.

The paper concludes with a clear discussion, based on the method of stationary phase, of the arrival curves, showing the values of the periods of the oscillations which would be expected to be dominant at various points on the axis of the bar for various values of t. This discussion brings out the disturbing feature that the values of the dominant periods derived from the integral solution are, on the whole, clustered around the arrival curve of the radial mode of the Herrmann-Mindlin theory, rather than the longitudinal mode. This is unfortunate because examination of the dispersion curves (e.g. Fig. 5) shows that the agreement between the longitudinal mode of the Mindlin-Herrmann theory and the first mode of the exact solution is not too bad, whereas the agreement between the radial mode of the approximate theory and the second mode of the exact theory is much poorer; the third and higher modes of the exact theory have, of course, no counterparts in the approximate theory. R. M. Davies, Wales

1130. Miklowitz, J., and Nisewanger, C. R., The propagation of compressional waves in a dispersive elastic rod Part II—Experimental results and comparison with theory, *J. appl. Mech.* **24**, 2, 240–244, June 1957.

The aim of this paper is to find how the theoretical results derived in the companion paper [see preceding review] tally with the results of an experimental investigation of the problem. For this purpose, one end of a bar of Al alloy (24 S-T) was subjected to a normal stress in the form of a step function, whose peak value was of order 300 psi, obtained by means of a shock tube. The time history of the longitudinal strain and the radial displacement at various distances from the end was recorded by means of resistor strain gages cemented to the cylindrical surface of the bar and by a condenser microphone, respectively.

A discussion of the results brings out a number of interesting points. It is shown, for example, that the initial part of the disturbance travels with a velocity which exceeds the "bar" velocity c_0 $(= (E/\rho)^{1/2}$, in the usual notation); at a distance of 20 in. from the origin, the velocity of the leading edge of the pulse was about 1.1 c_0. In the past it has been supposed that propagation with a group velocity greater than c_0 was incompatible with the Pochhammer-Chree theory; recently, however, it has become clear that this type of propagation is to be associated with plateaus on the dispersion curves derived on this theory for the higher modes. Over these plateaus, the phase and group velocities are constant and substantially equal to the velocity of dilatational waves in an infinite medium, and, furthermore, the plateaus of successive modes combine to form a more-or-less continuous straight line [Junger, M. C., *J. acoust. Soc. Amer.* **27**, p. 974, 1955; Redwood, M., and Lamb, J., *Proc. phys. Soc. Lond. (B)* **70**, p. 136, 1957].

Reverting to the experimental results, the records show, as usual, that the main pulse is accompanied by trains of oscillations of variable frequencies. An analysis of these frequencies is carried out and the results are compared with the theoretical results derived in the companion paper. It is found that the frequencies of the moderately short waves which predominate at the later times at a random station on the rod agree approximately with those given by the radial mode of the Mindlin-Herrmann theory; furthermore, the early part of the disturbance is found to be represented by the very short waves of the same mode. By and large, it would seem that relatively few oscillations corresponding to the longitudinal mode of the Mindlin-Herrmann theory (or the fundamental mode of the Pochhammer-Chree theory) have been excited in the present experiments. This result is in sharp contradiction to the results obtained with bullet impacts and small charges of explosive, where the oscillations are to be attributed mainly to the fundamental mode. The reason for the difference is to be found presumably in the difference between the space distribution and the time variation of the applied stress in the two cases; e.g. in the bullet and explosive experiments, the stress is concentrated over a relatively small area of the end of the bar, whereas, in shock-tube experiments, the distribution of stress is sensibly uniform over the end.

On the whole, the agreement between theory and experiment is not as good as one would wish; in spite of the labor and effort which have been spent on this problem, it still awaits a complete solution. R. M. Davies, Wales

1131. Mirsky, I., and Herrmann, G., Nonaxially symmetric motions of cylindrical shells, *J. acoust. Soc. Amer.* **29**, 10, 1116–1123, Oct. 1957.

Authors derive dynamic equations of a thin cylindrical shell, including effects of rotatory inertia and transverse shear deformation, in sufficient generality to handle nonaxially symmetric motions. Standard techniques are used throughout, including Hamilton's principle. Numerical values of axial phase velocities are given for several cases. J. H. Huth, USA

1132. Datta, A. N., Longitudinal propagation of elastic disturbance for linear variations of elastic parameters, *Indian J. theor. Phys.* **4**, 2, 43–50, June 1956.

Author obtains solutions for longitudinal plane waves in isotropic elastic medium of thickness H in direction of propagation, such that Lamé elastic constants are linear functions of x between $x = 0$ and $x = H$. Surface $x = 0$ is free, while $x = H$ is subjected to: (1) sinusoidal displacement, (2) sinusoidal stress, or (3) impulsive stress. Solutions in terms of Bessel functions of zero order simplify considerably (especially for impulsive loading case) when the linear variation of elastic constants is small, so that asymptotic expressions can be used for the Bessel functions. In last case, reflections are not considered; solution is valid only until pulse reaches other face. L. Malvern, USA

1133. Banerjee, K. N., Transients in the records of seismic body waves, *J. Technology* **1**, 1, 49–56, June 1956.

Paper deals with transient response of electromagnetic seismograph to damped harmonic motion of the ground. Applying Laplace transform to equation of motion for pendulum and galvanometer, author presents solution for galvanometer's deflection, being composed of three terms which correspond, respectively, to initial motion of pendulum, transient and steady-state components of solution.

Numerical calculation has been worked out for a typical case of S-wave deduced from Jeffreys' model to illustrate variation of the respective three terms with time. Total response of seismograph can be drawn as the combination of them. Discussion is made, briefly, on remarkable contribution of transient term as well as on the possibility of estimating the size of earthquake origin from comparison of theoretical response with observational results.
K. Kasahara, Japan

Elasticity Theory

(See also Revs. 1115, 1147, 1155, 1158, 1168, 1179)

1134. Bhattacharya, S. K., Further work on three-dimensional Mohr circles, *J. Instn. Engrs. India* **37**, 10, part 1, 939–947, June 1957.

Author gives a new exact graphical method for determining the normal (S_n) and tangential (S_s) stress components on the face of an elastic tetrahedron subjected to three known principal stresses. S_n is the sum of three projections and S_s is the sum and product of four quantities.

Reviewer believes that the original method of O. Mohr for determining S_n and S_s is more simple [Abhandlungen aus dem Gebiete der Technischen Mechanik, 3. Aufl., p. 200, fig. 8].

A. M. Guzman, Argentina

1135. Tolokonnikov, L. A., Connection between strains and deformations in the nonlinear theory of elasticity (in Russian), *Prikl. Mat. Mekh.* **20,** 3, 439–444, May-June 1956.

Author discusses the invariants of deformation that arise in the nonlinear theory of elasticity. The stress tensor is then given in terms of the strain tensor invariants. The same stress tensor is given in terms of two invariant functions; these latter functions are composed of certain nonlinear expressions involving the strains. A geometrical interpretation is given for the strain parameters, and the two functions referred to are capable of experimental verification.

Some special cases are derived which simplify the expressions for these functions, and likewise the stress relations involving them are also simplified. In order to fully comprehend the derivations, a reference to Novozhilov's work is required [title source **15,** nos. 2 and 6, 1951; see AMR **4,** Rev. 4401] besides a familiarity with his monograph, "Nonlinear theory of elasticity," (Translated version by Graylock Press).

J. J. Brandstatter, USA

1136. Jindra, F., Contribution to nonlinear torsion (in German), *Öst. Ing.-Arch.* **11,** 2, 134–146, Apr. 1957.

Using a nonlinear elasticity law, developed by H. Kauderer [*Ing.-Arch.* **17,** p. 450, 1949; see also C. B. Biezeno and R. Grammel, "Technische Dynamik," 2nd edition, Vol. I, p. 35, Berlin 1953], author treats the torsion problem of a prismatic bar of circular, elliptic, or square cross section. Numerical computation of the stresses, occurring under assumption of a (quite acceptable) simplification of Kauderer's general law, leads to the result that the peak stresses, as compared with those predicated by the linear theory, are smaller.

C. B. Biezeno, Holland

1137. Nishihara, T., and Fujii, T., Stresses in an infinite plate with an overlapped hole, Proc. Sixth Japan nat. Congr. appl. Mech., Univ. of Kyoto, Japan, Oct. 1956, 35–38.

Stresses in an infinite plate with an overlapped hole under axial tension by means of stress functions of curvilinear coordinates are shown. Holes of ellipse with overlapped circle, ellipse with overlapped square, and ellipse with ellipse are analyzed. Form factors for these cases are shown.

T. H. Lin, USA

1138. Hata, K., One method for solving three-dimensional elasticity problems in orthotropic solids, Proc. Sixth Japan nat. Congr. appl. Mech., Univ. of Kyoto, Japan, Oct. 1956, 43–46.

The generalized Hooke's law of Cauchy involving 21 constants is combined with the equilibrium stress equation to give the general form of Lamé's equation. This is solved by operational methods for the displacement. Author claims some solutions are found as readily as for isotropic materials. Application is given for symmetrical loading on the faces of a paralellopiped. Compatibility is not considered. Reviewer draws attention to his criticism of the generalized Hooke's law in his book [Analysis of Deformation: vol. 1, 'Mathematical Theory'," USA, Macmillan; London, Chapman & Hall, 1954].

K. H. Swainger, England

1139. Mutsenek, K. Ya., Estimation of a small degree of ellipticity in calculations of combined bodies having clearance (in Russian), *Izv. Akad. Nauk Latv. SSR* no. 11, 95–102, 1954; *Ref. Zh. Mekh.* 1956, Rev. 5343.

Author examines the influence of ellipticity of one of two cylindrical components combined by a stressed fit in the determination of the values of stress components.

The tightness is represented in the form of the sum of constant and variable tightness. For the latter, the law $k \sin 2\theta$ is assumed, where θ is the polar angle. The expression for the stress function from the variable tightness is assumed on the basis of P. F. Papkovich's solution ["Theory of elasticity," Oborongiz, 1939]. A numerical example is given from which it follows that the stresses taking into account the ellipticity are 11.3% greater.

N. D. Tarabasov

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

1140. Imshenetskaya, E. F., The jump for an integral of the theory of elasticity (in Russian), *Naukh. zap. Lvovsk. politekhn. in-ta* no. 30, 15–23, 1958; *Ref. Zh. Mekh.* no. 11, 1956, Rev. 7772.

In the conditions of the first boundary problem for an integral of the type of a potential of a binary layer, representing a stress vector acting at point x of an elastic body on an area with the normal $\nu(y_0)$, an expression is derived for the jump experienced in the passage of the point x through the boundary surface S. This corrects an error in one of the results obtained by V. D. Kupradze ["Boundary problems of the theory of perturbations," 1950, p. 157, theorem and equation 4.81].

N. A. Rostovtsev

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

1141. Amenzade, Yu. A., The regularity of the infinite system of equations in the bending of a circular prismatic bar with an elliptical cavity (in Azerbeidjani), *Doklady Akad. Nauk AzSSR* **11,** 3, 155–160, 1955; *Ref. Zh. Mekh.* no. 11, 1956, Rev. 7677.

D. I. Sherman's proof of the regularity of an infinite system of equations for the torsional problem of a round bar with an elliptical aperture [see *Ref. Zh. Mekh.* 1954, Rev. 2231] is repeated here for the case of bending, under concentrated load, of a circular prismatic bar with an elliptical cavity.

M. P. Sheremet'ev

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

1142. Alterman, I., Linear equations instead of integrations in the mathematical theory of elasticity, *Bull. Res. Counc. Israel* **6A,** 1, 50–54, Oct. 1956.

This paper considers only standard methods of analysis of integration of the differential equations of the classical beam theory.

J. H. Argyris, England

1143. Gomza, A., Stress concentration factors II, *Prod. Engng.* **28,** 7, 215–223, July 1957.

1144. Okubo, H., and Kikuchi, S., Stress-concentration factors in shafts, *J. appl. Mech.* **24,** 2, 313–314, June 1957.

1145. Rowe, J. H., How to find thickness of a constant-stress disk, *Prod. Engng.* **28,** 4, 211–215, Apr. 1957.

1146. Daniel, A. W. T., Stress-strain characteristics of a granular material, *Engineering* **184,** 4766, 45–46, July 1957.

Experimental Stress Analysis

1147. Horton, W. H., Experimental methods in kinetic heat tests, *Aircr. Engng.* **24,** 342, 232–240, Aug. 1957.

The components of an experimental setup are described which allows simulation of the unsteady temperature distribution in

structures of high-speed aircraft. Convective heat transfer and radiation are simulated by infrared radiators which are controlled from a computer according to a prescribed flight program.

E. R. G. Eckert, USA

1148. Udoguchi, T., and Kunio, T., Photoelastic stress analysis for axisymmetrical problems. I. A new method with parallel polarized light, Proc. Sixth Japan nat. Congr. appl. Mech., Univ. of Kyoto, Japan, Oct. 1956, 125–129.

Authors describe a modified technique for applying the "fixation" or "stress freezing" method of three-dimensional photoelasticity to axisymmetrical problems, in which any plane containing the axis of symmetry is a principal plane of stress. The conventional procedures of stress freezing and cutting out a slice containing the axis of symmetry are employed and the usual two-dimensional methods for establishing the stress distribution in this slice are followed. However, instead of determining the principal stress in the direction normal to the initial slice by taking a series of slices at right angles to the first and determining the relative retardation in each slice, the equivalent result is obtained by a process of diminution. According to this method, the equivalent of the birefringence in each slice is determined by establishing the stress pattern, at normal incidence to the flat surface, in one of the two (approximately) halves of the model which are left after removal of the central slice. Successive layers are then ground off the flat surface and after each reduction the birefringence in the remainder is determined. By observing the change produced in the stress pattern after grinding off each layer, the equivalent of the relative retardation in each layer is found.

A numerical example showing a comparison between the results of this method, theoretical calculation, and the experimental work of other investigators is given.

W. M. Murray, USA

1149. Nisida, M., Hondo, M., and Hasunuma, T., Studies of plastic deformation by the photoplastic method, Proc. Sixth Japan nat. Congr. appl. Mech., Univ. of Kyoto, Japan, Oct. 1956, 137–140.

A proposal is made to use celluloid to represent an elastoplastic material such as a non-strain-hardening metal, and to determine stress and strain patterns in the plastic range by photoelastic procedures. The few simple examples tested indicate that not only can the plastic stress and strain distribution be determined but also the residual stress pattern after unloading can be found. Although the time for a complete test is relatively long, the method shows considerable promise for at least qualitative studies of elastoplastic materials in the plastic range.

E. E. Sechler, USA

1150. Hansen, P. L., The carrying capacity of curved beams, *Acta Polyt., Civ. Engng. Bldg. Const. Ser.*, **3**, 7, 12 pp., 1956.

Author checks plastic theory of curved steel beams, loaded with a concentrated force, by model tests. Theoretical results are obtained, assuming full plastic hinges and considering also influence of axial forces in the common way. Test results agree very well with computed values, and collapse load of model tests differs only from 1 to 4% from theoretical values. Tests were executed only for small axial forces and preponderant bending moments.

According to author's opinion it seems impossible at present to also test arch beams with great axial forces, and reviewer believes that this is one of the most important problems of plastic design. It is obvious that tested models had a ratio r/h too large for the nonlinear stress-distribution of curved beams to have an appreciable influence on the formation of plastic hinges.

Tests confirm again admissibility of simplified fundamental assumptions for plastic design, even for curved beams.

H. Beer, Austria

1151. Sciammarella, C. A., New method for the experimental solution of hyperstatical structures, composed of prismatical pieces, *Cienc. y Técn.* **123**, 618, 110–117, May 1957.

A unit couple is applied successively at each joint of a celluloid model of the structure and, with the aid of a mirror, rotations and displacements are measured at all joints. Thus the matrix of a system of slope-deflection equations can be obtained experimentally.

J. Michalos, USA

Rods, Beams, Cables, Machine Elements

(See also Revs. 1112, 1113, 1117, 1120, 1121, 1122, 1141, 1142, 1144, 1150, 1189, 1196, 1197, 1200, 1206)

1152. Lee, S.-L., Analysis of continuous beams by Fourier series, *Proc. Amer. Soc. civ. Engrs.* **83**, EM 4 (*J. Engng. Mech. Div.*), Pap. 1399, 14 pp., Oct. 1957.

This paper deals with the analysis of continuous beams by means of the expansion of arbitrary load function and the intermediate redundant reactions in infinite trigonometric series. The values of the redundant reactions corresponding to any load distribution are determined by the application of Castigliano's theorem. The same procedure is used to derive expressions for the influence lines for the reactions.

G. G. Meyerhof, Canada

1153. Savelyev, N. G., The calculation of elastically supported beams bent in compression (in Russian), Calculations for strength, rigidity, stability and oscillation, Moscow, Mashgiz, 1955, 143–152; *Ref. Zh. Mekh.* no. 11, 1956, Rev. 7870.

An approximate method is demonstrated for solving problems of longitudinal-transverse bending of bars on a continuous elastic support, consisting of applying the method of consecutive approximations of A. N. Krylov. The approximation can be carried to any required degree of accuracy.

The suggested fundamental functions are polynomials, orthogonal for the whole length of the bar.

On the basis of the mean square error, the solution is obtained in the form of a series consisting of Chebychev polynomials; it is demonstrated that the solution obtained is singular.

S. M. Zavartsev

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

1154. Korotkin, Ya. I., Lokshin, A. Z., and Sievers, N. L., Bending and resistance of bars and bar frames (Structural mechanics of ships) (in Russian), Textbook for shipbuilding colleges, Moscow-Leningrad, Mashgiz, 519 pp. + illus., 1953; *Ref. Zh. Mekh.* 1956, Rev. 4765.

Book contains an introduction, eight chapters, and appendices. The subjects treated are: the general theory and energy relationships of the mechanics of structures, the theory of flexure of rectilinear beams, calculation of two-dimensional frameworks of straight bars, calculation of frameworks of curved bars, theory of bending of bars lying on a continuous elastic foundation, calculation of flat floors, theory of complex bending of bars, and the theory of the stability of bars and simple bar frames.

The contents correspond, with a few contractions, to the two volumes of the first part of the textbook by P. F. Papkovich ("Structural mechanics of the ship," Moscow-Leningrad, pub. "Morskoy Transport" pt. I, Vol. I, 1945: Vol. II, 1947), and partly to the first two chapters of the second part of the textbook by P. F. Papkovich ("Structural mechanics of the ship" pt. II, Leningrad, State Assn. Pub. Off. Shipb. Industry, 1941, 160 pp., of which the first two chapters occupy 413 pp.)

There is some added material to that already given in the textbooks of P. F. Papkovich. One of these additions concerns the calculation of decks with non-slipping cross joints, using series expansion according to the modes of natural oscillation (method of A. A. Kvrdyumov, which is a variation and development of the method of calculation of regular floors with a large number of joists in both directions, according to P. F. Papkovich).

The layout used and classification of systems agree entirely with those of Papkovich's textbook. A. P. Filin

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

1155. Masur, E. F., The strength of very slender beams, *Proc. Amer. Soc. civ. Engrs.* **83,** EM 4 (*J. Engng. Mech. Div.*), Pap. 1413, 25 pp., Oct. 1957.

In the ordinary simplified theory of a beam subject to combined bending and torsion, the strain-displacement relations are assumed to be linear and the equations of equilibrium refer to the undistorted configuration. This leads to the simple linear theory and is valid when the lateral stiffness of the beam is comparable in magnitude to the major stiffness. When this condition is not true a second-approximation type of solution is needed. In this, the large lateral deflections and rotations make it necessary to refer the equilibrium equations to the deformed configuration.

The present paper offers a third-approximation type of solution since it abandons the assumption of linear strain-displacement relations. With regard to lateral displacements and rotations, the results of the second and third approximations are identical for beams which are statically determinate relative to moments in their major plane of stiffness. However, for redundant beams the third approximation leads to substantial modifications. In general, the inclusion of nonlinear terms corresponds to a stiffening of the structure. For certain singular cases the possibility of snap-through is shown to exist. W. A. Nash, USA

1156. Zyczkowski, M., Computation of critical forces for elastic nonprismatic bars by the method of partial interpolation (in Polish), *Rozpr. Inzyn.* **4,** 3, 367–412, 1956.

Paper is devoted to determining the critical force in an elastic nonprismatic bar, clamped at one end or on hinged supports at both ends. It is assumed that the bars are (1) uniformly convergent in the space or (2) uniformly convergent in a plane; by this term author understands the linear variability of the cross-sectional dimensions.

The solution of the accurate differential equation of the problem is reduced to obtaining the roots of some transcendental equation.

An analysis of the existing solution methods of the equation, i.e. those of MacMahon, A. Kalähne and B. P. Bogert, is also given.

The author proposes his own "method of interpolation." Using this method, tables with six decimals for the computation of the critical force in function of the convergence of the bar are presented. W. Urbanowski, Poland

1157. Midgley, P. J., An analysis of flexural systems under arbitrary distortion and end loading, *J. roy. aero. Soc.* **61,** 559, 475–484, July 1957.

Particular reference is made to bending moment distributions along the span of a flexing beam, and to the effects of lengthwise strains. Cross-spring and "spider"-type flexural systems are treated in detail. Curves are presented which enable the stiffness and stressing of any flexural system to be calculated for any loading conditions, subject only to the restriction that deflections are small, so that the linearized beam equation may be applied.

From author's summary by J. F. Besseling, USA

1158. Privezentsev, V. A., and Zverev, V. V., Some problems of the theory of twist of electrical cables (in Russian), *Vestn. elektroprom-sti* **2,** 17–21, 1954; *Ref. Zh. Mekh.* 1956, Rev. 5555.

Examination of the deformation of current-bearing cores of insulated cables and overhead transmission lines which occurs in the process of coiling. Also cases of deformation are analyzed which occur during the twisting of cores with and without untwisting.

The following basic conclusions are drawn:

(1) When examining the processes of twisting with and without untwisting it is necessary to consider the angle of slope α of the helix, since the twist of the wire depends on the size of this angle.

(2) During twisting without untwisting, the maximum twist per unit length of the wire occurs at $\alpha = 45^\circ$ (at a coefficient of twist $m = \pi$); however, twist in revolutions for the length of one pitch of the helix is greater, the greater the pitch of the twist. At the values of twist pitch used in practice, the coiling of the wire is close to one revolution (360°).

(3) In the case of twisting without untwisting with a very small pitch ($m < 1.8$), torsional deformation will be less than with untwisting.

(4) In the case of twisting without untwisting the wire, in addition to the twist it is also subjected to bending deformation. In the case of twist with untwisting, for the pitches used in practice the twist of the wire is negligible. In addition in the case of complete untwisting, bending deformation is lacking and the curved shape of the wire is brought about as a result of additional shear deformation. A. I. Kolchin

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

1159. Zhdanov, G. P., Bending stresses in steel wire cables (spiral and double twist) (in Russian), *Nauch. tr. Kharkovsk. gorn. in-ta* **2,** 127–135, 1955; *Ref. Zh. Mekh.* 1956, Rev. 5553.

The cable is regarded as a total number of wires, the axes of which represent three-dimensional curves: a helix for a single twist cable and a complex curve for cables of double twist.

The development of equations for the axes of the wires of spiral cables of double twist during bending on a pulley is given.

Formulas are obtained for determination of the maximum curvature of the axis of the wire in the single and double twist cables. The maximum bending stresses are determined for elastic and elastic-plastic deformation; in the latter case, the diagram of true stresses is used.

The maximum bending stresses occur at points facing the external arc of a cable bent on a pulley.

P. O. Nesterov

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

1160. Bezsonov, V. G., An investigation of the bending stresses in the wires of steel wire ropes (in Russian), Stress and strain measurements in machinery elements, Moscow, Mashgiz, 1955, 177–187; *Ref. Zh. Mekh.* no. 11, 1956, Rev. 7956.

Instruments, methodology, and procedures are described, used in the experimental investigation of bending stresses in the outer wires of steel wire ropes, by means of corresponding, short base (5 – 3 mm) ohmic-resistance strain gages.

The experiments were made on two spiral-lay ropes with diameters of 7.4 and 13.5 mm, and cable-lay ropes of the types $6 \times 19 + 1$ and $6 \times 37 + 1$, with diameters of 18.5, 25.0 and 37.5 mm.

The experimental results show that:

(1) The bending stresses in the outer wires of the rope do not depend on the degree of prestressing, at least not for $Q \leqslant R_{sum}/6$, where R_{sum} is the total combined rupture strength of the rope.

(2) The values recommended by the Technical Rules of the PTE, of $D/\delta \approx 1200$, and $D/d = 80$, where δ = diameter of the wire in the rope, d diameter of the rope, D diameter of the drum or sheave over which the rope works, prove to be uncoordinated from the aspect of the ultimate bending stress, and, indeed, contradictory; thus, the maximum bending stresses in the outer wires of the ropes tested, for $D/\delta = 1200$, were found to vary from 8.5 to 11 kh/mm², and for $D/d = 80$, between 7.0 and 60 kg/mm².

(3) For a ratio of D/δ = const, the scattering of the bending stress values was found to be fractionally less than for D/d = const; hence, for cable-laid rope of the formula $6 \times 10 + 1$ and $6 \times 37 + 1$, the ratio D/δ is a better criterion of the bending stresses in the constituent wires of the rope.

G. N. Savin

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

1161. Golecki, J., Boundary-value problems for elastic rings, (in English), *Arch. Mech. stos.* **8,** 2, 123–142, 1956.

The solution of the generalized Lamé equation for two-dimensional problems

$$\Delta u_i + \frac{m'}{m-2}\frac{\partial e^*}{\partial x_i} = C \quad (i = 1, 2)$$

($m' = m + 1$ for plane stress, $m' = m$ for plane strain, $e^* = \epsilon_1 + \epsilon_2$) is sought in the form

$$u_i = \frac{1}{2G}\left(r^2\frac{\partial \psi}{\partial x_i} + x_i\omega + \frac{\partial \phi}{\partial x_i}\right) \quad (i = 1, 2)$$

where $r^2 = x_1^2 + x_2^2$, $\psi = \sum_\nu \mu_\nu \psi_\nu$, $\omega = \sum_\nu \lambda_\nu \psi_\nu$, $\phi = \phi_0 + \sum_\nu \phi_\nu$, and ψ_ν and ϕ_ν are homogeneous harmonic functions of the order ν, and ϕ_0 is a sum of harmonic functions; μ_ν and λ_ν satisfy some simple equations given in the paper.

Assuming

$$\psi_\nu = a_\nu\left(\frac{R_0}{r}\right)^\nu \begin{matrix}\sin\nu\varphi \\ \cos\nu\varphi\end{matrix}, \quad \phi_\nu = b_\nu\left(\frac{R_0}{r}\right)^\nu R_0^2 \begin{matrix}\sin\nu\varphi \\ \cos\nu\varphi\end{matrix}$$

for the external problem ($r \geq R_0$), and respective expressions for the internal problem ($r \leq R_0$), general expressions for displacement, stress and strain are obtained. This general solution is used for solving the following particular cases: (1) a ring, for which displacement and stress at the edge can be expressed in the form of Fourier series, (2) a multilayer circular ring, (3) a circular disk diameter.

W. Urbanowski, Poland

1162. Komatsu, S., Deformation of the cross section in box girder (in Japanese), *J. Japan Soc. civ. Engrs.* **40,** 11, 615–621, Nov. 1955.

By applying the Ritz procedure, an approximate solution is obtained for the deformation of the cross section in a box girder, which is reinforced with equidistant rigid diaphragms, under pure bending.

In the design of bridge structures, the reduction of the flexural rigidity caused by such deformation must be strictly considered in the case of a flat rectangular box section.

Graphs for the rate of reduction are plotted against various practical values of the interval between diaphragms as well as the dimensions of box section. Thus the admissible longest interval between diaphragms may be rationally determined by using the formula derived from this point of view.

S. Okamoto, Japan

1163. Niemann, G., and Rettig, H., Dynamic gear tooth loads: I. Experimental results on the influence of speed, static loading, tooth error, and inertia on dynamic tooth load; II. Discussion of the results and control experiments (in German) *ZVDI* **99,** 3, 89–96, Jan. 1957; **99,** 4, 131–137, Feb. 1957.

This progress report describes extensive and careful dynamic load tests of small (about 8 pitch, 3-in. diam) steel gears. Principal parameters varied during tests include speed (to 2200 rpm), nominal (static) load (to 3000 lb per in. of width), tooth spacing error (to 0.006 in.), and rotating inertia (about 10 to 1 reduction in natural frequency). Root and contact stresses and tooth load are determined from tooth deflection measurement (miniature differential transformer).

Principal conclusions are that (1) dynamic effects occur even without tooth error, (2) dynamic effects are especially prominent for low-load gears, (3) dynamic load increases less-than-proportional to nominal load, (4) tooth error affects root stress more strongly than contact stress, (5) effect of speed on root stress is less than on contact stress, but even latter effect is less, relatively, than that of tooth error, and (6) effects of rotating inertia are more noticeable for low nominal tooth loads. Conclusions are verified by control experiments (failure tests).

Authors indicate that further work, especially for application to larger gears and for formulation of design techniques, will be reported shortly. In conjunction with the results already available, this may be expected to constitute a most valuable addition to gear technology.

G. A. Nothmann, USA

1164. Utagawa, M., Measurements of dynamic loads on gear teeth, Proc. Sixth Japan nat. Congr. appl. Mech., Univ. of Kyoto, Japan, Oct. 1956, 489–492.

The problem of dynamic loads in moving, mating gears is claimed not to be satisfactorily solved. Using electric strain gages, author measures stresses at root fillet. Measured stresses plot close to those calculated as the sum of flexure, direct compression, and eccentric compression components. It is further found that the increment dynamic load varies with velocity as well as contact ratio. Frequency of dynamic load variation is also shown to very nearly coincide with natural frequency of gear-pinion system.

J. P. Vidosic, USA

1165. Nakada, T., and Utagawa, M., The dynamic loads on gear caused by the varying elasticity of the mating teeth, Proc. Sixth Japan nat. Congr. appl. Mech., Univ. of Kyoto, Japan, Oct. 1956, 493–497.

Varying elasticity of mating gear teeth results in a varying load cycle. Author solves the gear-pinion combination as a vibrating system with variable stiffness. Some explanation of the measured stress cycle in flank of tooth is found in this solution. Oscillograms reveal close agreement between stress cycle and values calculated using elastic, vibration properties of gear teeth.

J. P. Vidosic, USA

1166. Shiriaev, G. A., Torsion of a shaft weakened by a crack (in Russian), *Prikl. Mat. Mekh.* **20,** 4, 555–558, July–Aug. 1956.

The conformal mapping into a unity circle is given for a circle with crack in form of a circular arc, intersecting the boundary at right angle. Muskhelishvili's complex variable method is used for solving the torsion problem, especially for the case of zero curvature of the arc, i.e. of radial crack. Torsional rigidities calculated for several depths of it agree with results of other authors obtained in a different way.

J. M. Klitchieff, Yugoslavia

Plates, Disks, Shells, Membranes

(See also Revs. 1124, 1131, 1167, 1184, 1185, 1187, 1205, 1211)

1167. Scherer, A., Influence surfaces of a triangular plate with a unit force on the free edge (in German), *Ing.-Arch.* **25,** 4, 255–272, June 1957.

A new singularity method based on conformal mapping [AMR **7**, Rev. 3517] is used to calculate the influence fields of deflection and bending moment for a triangular plate with two clamped and one free boundaries. The force is applied in the middle of the free edge. Herefore a new fundamental integral had to be derived. The results show high accuracy and give a complete picture of the influence fields as the conformal mapping of the triangle on to the unit circle was calculated in all details numerically.

F. Schultz-Grunow, Germany

1168. Ashwell, D. G., The equilibrium equations of the inextensional theory for thin flat plates, *Quart. J. Mech. appl. Math.* **10,** 2, 169–180, May 1957.

E. H. Mansfield [*Quart. J. Mech. appl. Math.* **8,** p. 338; 1955] and Mansfield and P. W. Kleeman [AMR **9,** Rev. 421] discussed problems of bending of inextensible thin plates. The energy method was applied to solution. The method is subject to criticism in that it does not give an insight into a mechanism of how a plate supports the load. The author of this paper supplements these solutions by applying the method of equilibrium and compatibility conditions alone. To quote the author, the following has been accomplished, "The functions of the membrane forces in the plates are described, and the existence of shearing forces concentrated along their free edges is deduced. Equations of equilibrium are obtained, from which the magnitude of the membrane stress (except near the edges), and of the edge-shears, may be estimated. A new form of the differential equation for the deformation of such a plate is given in terms of the edge regression of the developable surface into which it deforms. The accuracy to be expected from the theory, when applied to practical plates, is discussed."

R. M. Evan-Iwanowski, USA

1169. Zurmuhl, R., Solution of the plate problem according to the improved difference method (in German), *ZAMM* **37,** 1/2, 1–16, Jan./Feb. 1957.

Paper deals with the problem of a rectangular plate, loaded transversely, by means of an improved difference method, which enables both the treatment of boundary conditions and the determination of bending moments with high accuracy. Solution for various possibilities of supporting is illustrated by numerical examples. Results obtained are in good agreement with the exact solution.

From author's summary by V. Kopriva, Czechoslovakia

1170. Paria, G., Stress distribution in a thin parabolic plate due to a concentrated force at the focus, *Bull. Calcutta math. Soc.* **48,** 4, 181–190, Dec. 1956.

Title problem is formulated as one in plane strain and solved by superimposing a residual problem on Love's solution to the problem of a force operative at a point in an infinite plate. Transformation to a state of generalized plane stress is accomplished in the usual way by appropriate modifications of the elastic constants. The residual problem is solved by means of the complex variable and is somewhat involved. Reviewer feels that a much more straightforward approach would be to work directly in parabolic coordinates.

J. H. Baltrukonis, USA

1171. Natsume, S., and Tanimoto, B., A note on the stress distribution in a plate with circular plug or concentric ring under edge forces, Proc. Sixth Japan nat. Congr. appl. Mech., Univ. of Kyoto, Japan, Oct. 1956, 87–90.

Authors give a solution for the distribution of stresses around a circular hole subjected to a pair of parallel and uniform edge forces, the hole being filled with a heterogeneons solid plug or a concentric ring. In earlier papers the same problem had been treated with simplified boundary conditions (Sezawa, Nishimura, Gurney, Savin); now the principle of minimum strain energy is used. At the boundary the normal and tangential stress components and also the radial displacement have perfect continuity, but not the tangential displacement. This fourth condition is replaced by the minimum principle. The results are evaluated numerically.

H. Neuber, Germany

1172. Kurata, M., and Hatano, S., Bending of uniformly loaded and simply supported but partially clamped rectangular plate, Proc. Sixth Japan nat. Congr. appl. Mech., Univ. of Kyoto, Japan, Oct. 1956, 57–60.

A uniformly loaded rectangular plate $ABCD$ clamped along equal lengths AP and DQ of opposite edges, and simply supported elsewhere at its edges, is solved by superposing known solutions for plates having opposite edges either simply supported or clamped. Calculations for a square plate having $AP/AB = 0.5$ show high edge bending moments near junctions of clamped and simply supported regions.

L. Maunder, Scotland

1173. Shinomiya, T., Numerical solution of a plate by relaxation method, Proc. Sixth Japan nat. Congr. appl. Mech., Univ. of Kyoto, Japan, 13–16, Oct. 1956.

Point-, group-, and over-relaxation methods have been studied with reference to the sum of moments of a rectangular plate and the deflection of an irregular plate. Results show that the accuracy increases when group relaxation is used instead of point relaxation. The accuracy may be further enhanced by over-relaxation.

Y. V. G. Acharya, India

1174. Kurdyumov, A. A., The experimental solution of plate-bending problems (in Russian), *Trudi Leningr. Korablestroit. in-ta* **16,** 3–10, 1955; *Ref. Zh. Mekh.* no. 11, 1956, Rev. 7736.

The conditions are examined for simulating plates acted upon by forces in their own plane, and by a transverse load. The differential equations for the analysis of plates with large bending deflection are reduced to a nondimensional form, the fundamental parameters being represented by the term

$$\lambda = [12\,(1-(\mu^2)^{1.5}\,\frac{qb^4}{Eb^4}$$

and the aspect ratio of the plate by $\gamma = a/b$ (q= intensity of the transverse load, μ = Poisson's ratio). Further, different variants are examined of homogeneous and inhomogeneous boundary conditions for the bending deflection and the stress functions in the plane of the plate. In application to the problem of the hypercritical deformation of compressed plates, an additional parameter

$$\varepsilon = \frac{1}{12(1-\mu^2)}\left(\frac{b}{b}\right)^2\frac{u_0}{a}$$

is introduced, in which u_0 is the reciprocal displacement of the loaded rectilinear edges of the plates.

A. S. Vol'mir

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

1175. Rusinko, K. N., The deformation in an infinite plate with an elliptical opening, the edge of which is reinforced by means of a thin ring (in Russian), Byul. nauk. stud. konferentsii, 1954, L'viv, Vid-vo un-tu, 1955, no. 2, 98–100; *Ref. Zh. Mekh.* 1956, Rev. 6133.

The condition under stress is determined in a plate which is capable of being infinitely stretched in two mutually perpendicular directions, the plate being weakened by an elliptical opening, reinforced by means of a thin ring of constant section. The reinforcing ring is looked upon as an elastic brace working under bending and tensional stresses. Two examples are scrutinized: (1) the

elliptical ring under an evenly distributed load and (2) the elliptical ring with two concentrated forces acting along the long axis of the ellipse.

A. F. Rozhnyatovskii

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

1176. Lunchick, M. E., and Short, R. D., Jr. Behavior of cylinders with initial shell deflection, ASME Summer Conf., Berkeley, Calif., June 1957. Pap. 57-APM-35, 6 pp.

Using the mathematical expression for the initial deflection curve for the shell of a stiffened cylinder, a theoretical analysis was made for a cylinder subjected to external hydrostatic pressure, and the expressions for the additional stresses and strains developed in the shell due to initial accordion deflection are obtained by the author in this paper.

A. M. Sen Gupta, India

1177. Mizoguchi, K., Strength of semicircular cylindrical shells under torsion (General theory of cylindrical shells, statics. Example 3), Proc. sixth Japan Nat. Congr. appl. mech., Univ. of Kyoto, Japan, Oct. 1956, 153–156.

The strength of semicircular cylindrical shell subjected to a pair of twisting moments on its straight edges is determined. Author shows that Timoshenko's equations are inapplicable to the present problem, while complete inextensional theory may be used to calculate deflections and stress-couples.

O. K. Mawardi, USA

1178. Alumyae, N. A., Determination of the critical load for a shell outlined by a hyperboloid of one sheet (in Russian), *Prikl. Mat. Mekh.* **20,** 2, 223–235, Mar.-Apr. 1956.

Author considers a thin-walled shell of revolution outlined by a hyperboloid of one sheet which is symmetrical about the throat line and closed by flat heads which are rigid in their plane but elastic when bent out from their plane. If the middle plane is given by the equation

$$r = \left(\frac{c\gamma}{\cos\alpha}\right)(\mathbf{u}_x \cos\beta + \mathbf{u}_y \sin\beta) + \mathbf{u}_z c \tan\alpha \ldots . \qquad [1]$$

then the equations of the contour curves are $\alpha = \alpha_*$, $\alpha = -\alpha_*$. The shell is assumed to be under uniform outside pressure.

It is shown that the critical pressure depends on whether α_* is the root of the equation $\cos s\alpha = 0$ (or $\sin s\alpha = 0$), s being whole small values ($S \geqslant 2$), or α_* is different from the root to a larger or smaller extent of the equation $\cos s\alpha = 0$ (or $\sin s\alpha = 0$) at whole small values of s. For each of the above-mentioned problems, an individual method for the determination of the critical pressure is established. The submitted calculations are comparatively simple, but not elementary. This is explained partially by the fact that for the derivation of these methods it is necessary to use the methods of the membrane theory which is the most adaptable for the analysis of the first and second problem. In the examples referring to the intervals $40^\circ \leqslant \alpha_* \leqslant 45^\circ$, the role of the parameter of Eq. [1] is explained. The results of the calculations show that, for the thicknesses encountered in practice and for $\gamma \leqslant 0.5$, it is not necessary to apply the calculations of the algorithms of the third problem.

M. Maletz, USA

1179. Ananina, A. N., Axisymmetric deformation of cylindrical shells in elastic and plastic deformation (in Russian), *Inzhener. Sbornik, Akad. Nauk SSSR* **18,** 157–160, 1954.

Presented approximate solution is based on the assumption that the elastic state is transformed into plastic state over the whole thickness of the shell, with the limitation that the yield point is not reached in any fiber. Comparison with exact solution by A. A. Illyushin justifies this approximate solution. Reference is also made to A. Liva ["Mathematical theory of elasticity." ONTI, 1935].

J. J. Polivka, USA

1180. Vassiliev, I. G., Calculation of the transverse rib spacing in continuous corrugated shells (in Russian), *Izv. Akad. Nauk SSSR, Otd. tekh. Nauk.* no. 1, 145–149, 1955; *Ref. Zh. Mekh.* no. 11, 1956, Rev. 7708.

From the stability condition for a longitudinal stiffener regarded as a bar in an elastic medium, the optimum spacing of the transverse ribs of a prismatic continuous corrugated shell is calculated.

The critical forces are determined from the theory of a thin-walled, compressed bar in an elastic medium. The required coefficients of the elastic medium are calculated from the displacements of the transverse ribs by corresponding individual forces, such transverse ribs being regarded as hingeless fictitious arches.

If the number of half-waves in the sinusoid of the compressed longitudinal rib is less than the number of transverse ribs in the corrugation, it is recommended to determine the pitch of the transverse ribs within limits of 0.072 to 0.1 of the length of the corrugation.

Kh. Kh. Laul'

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

1181. Shelyakov, Yu. A., The stress concentration in a cylindrical shell with a circular hole in the lateral surface (in Ukrainian), *Dopovidi Akad. Nauk URSR* no. 2, 123–125, 1955; *Ref. Zh. Mekh.* no. 11, 1956, Rev. 7707.

Author determines the stresses around a circular hole in the lateral surface of a cylindrical shell, if the edge of the hole is reinforced by an absolutely rigid ring.

The problem is solved, essentially, by a system of partial equations, obtained by solving the problem of the stress concentration around a nonreinforced, circular hole in a cylindrical shell [cf. A.I. Louric "Statics of thin-walled elastic shells", Gostekhizdat, 1947].

M. P. Sheremet'ev

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

1182. Grigolyuk, E. I., The elastic resistance of orthotropic and laminar, conical and cylindrical shells (in Russian), Calculation of three-dimensional frameworks, no. 3., Gos. izd-vo lit. po str-vu i arkhitekture, 1955, 375–420; *Ref. Zh. Mekh.* no. 11, 1956, Rev. 7703.

A simplified variant is derived for the nonlinear relationships between the components of the deformation tensors and the displacement vector, for a conical, rotational shell; the simplification consists in neglecting, in these relationships, the products of the tangential components, as well as their partial derivatives, of the displacement vector. The equilibrium conditions are derived with the help of the principle of possible displacements, it being assumed that the geometrical relationships can be further simplified. The relationships between the elasticities of orthotropic and multilaminar envelopes are stated.

The following external loading cases are examined: A uniformly distributed lateral or multilateral pressure, axial compression, torsion, causing in the case of some shells a non-momentum (inertialess) stress condition in the subcritical region. To determine the critical value for the inertialess state, a simplification is introduced for the analytical relationships, resembling that assumed in the theory of local loss of stability developed by Mashtari and Vlassov.

Solutions are presented for the fundamental problems of the stability (resistance) of a freely supported cylindrical bimetallic shell (envelope). For the solution of problems on the resistance of freely supported conical shells, the energy method is used, with approximation of the displacement components in monomial form:

$$W = Ar^2 \sin\frac{m\pi}{l}(s - s_1)\sin n\varphi$$

$$U = Br^2 \cos \frac{m\pi}{l}(s - s_1) \sin \quad n\varphi$$

$$V = Cr^2 \sin \frac{m\pi}{l}(s - s_1) \cos \quad n\varphi$$

In these, φ = longitude of the point on the surface of calculation, r axial distance of the same point, s distance from the (imaginary) apex of the cone, $s_1 \leqslant s \leqslant s_1 + l$, l length of the generating line; m, n = integral parameters, determined from the condition of minimum critical loading.

Values are given in the form of expansions for the determinate integrals in the equation of potential energy, as well as the coefficients of the characteristic equation both for the general and the particular case of a bilaminar envelope with identical Poisson ratios. Tables and curves are presented for determining the critical external pressure on a homogeneous conical envelope with an inclination of the generative to the base within the limits of 20°–80° and various ratios of the radius of the upper base of the envelop to its height (from 0.5 to 0.005 for $\alpha \leqslant 60°$, and 0.2 to 0.005, for $\alpha \geqslant 70°$) as well as of the product of sin α by the thickness, to the radius of the upper base (between 0.06 and 0.005). The corresponding values of n are also given. These data can, with particular conditions of elasticity, also be generalized for the case of a bilaminar shell.

It is observed that, at $\alpha \geqslant 75°$, the critical pressures on the conical and the cylindrical shell differ by little, if the radius of the latter equals half the sum of the base radii and the length is identical with the height of the conical envelope.

N. A. Alumyae

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

Buckling Problems

(See also Revs. 1199, 1207)

1183. Rozenblium, V. I., Stability of compressed struts in the presence of creep (in Russian), *Inzhener. Sbornik, Akad. Nauk SSSR* **18**, 99–104, 1954.

Paper presents an approximate solution of the problem of stability under conditions of creep of a strut of symmetrical cross section hinged at both ends. The material of the strut, although being elastic, is subject to creep in accordance with the law which assumes the time rate of creep to be proportional to stress, with the coefficient of proportionality being itself a function of stress as well as of time. The strut is assumed to possess an initial curvature in the form of a sine curve. As time goes, the immediate deflection caused by thrust is increased further by the creep until at some finite time later the strut collapses. The formulas for the time of development of the deflection, given in the paper, are derived by calculus of variations.

A. Hrennikoff, Canada

1184. Cutcliffe, J. L., and Heaps, H. S., Symmetrical buckling of a series of uniformly loaded parallel struts supported by spot connections to a long thin plate, ASME Summer Conf., Berkeley, Calif., June 1957, Pap. 57-APM-7, 6 pp.

Paper deals with problem stated in title by considering deflections of plate under loads applied by struts through connections and of struts under reactions to these loads, together with applied compressive forces. Plate deflections are obtained using Laplace transform method and equated to those of strut. Results presented show limits of plate thickness for which a given number of connections is necessary.

Authors claim that these results give information on buckling of skin-stiffener combination whose plate also carries compressive stress. Reviewer doubts this.

K. H. Griffin, England

1185. Levin, A. O., The stability of a plate compressed in two directions and with reinforced rib stiffness (in Russian), *Trudi Leningr. Korablestroit. in-ta* no. 15, 195–200, 1955; *Ref. Zh. Mekh.* 1956, Rev. 6156.

A kinetic method is employed to solve the problem of the stability of a rectangular plate compressed in two directions, the short edges of which are freely open, and the long ones elastically sealed. It is shown that in cases met with in practice the harmful influence of transverse stresses in the outer shell of the bottom of the ship cannot be compensated by stiffening the torsion of the longitudinal joists.

M. S. Kornishin

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

1186. Ylinen, A., A method of determining the buckling stress and the required cross-sectional area for centrally loaded straight columns in elastic and inelastic range, *Publ. int. Assn. Bridge struct. Engng.* **16**, 529–550, 1956.

A new function for the approximation of the stress-strain diagram is presented, starting from the derivative

$$d\sigma/d\varepsilon = E\,(\sigma_y - \sigma)\,(\sigma_y - c\cdot\sigma)$$

where σ_y is the yield-point stress and c a constant slightly less than unity (except for concrete where $c = 0$), c depending too on the proportional limit. With this formula the different inelastic buckling theories for several materials are discussed (tangent-modulus, double modulus, Shanley) with the already known conclusion that the tangent-modulus load (first Engesser theory) should be considered as the critical load of a centrally loaded straight column.

F. Stussi, Switzerland

1187. Vorovich, I. I., The behavior of a circular slab after loss of stability (in Russian), *Uch.-zap. Rostovsk. n/D in-ta* **32**, 4, 55–60, 1955; *Ref. Zh. Mekh.* no. 11, 1956, Rev. 7712.

The extensive bending of a circular, solid or annular, flat plate is investigated, acted upon by radial compression forces and a transverse load. The plate is regarded as supported along contour lines by elastic and elastically rotatable ribs with a nonlinear characteristic. In addition, the presence is assumed of an elastic, nonlinear support with a reaction equalling $R = kw + A(w)$.

The axially symmetrical equilibrium forms of such a plate are examined, in the presence of radial forces $T_i = T_{i0} + T_{i1}$, approaching the first critical value T_{i0}. The stress function in the central surface is represented in the form $F = \Phi + F_0 + F_1$, where F_0 and F_1 correspond to the forces T_{i0} and T_{i1}, while Φ is an additional term representing the nonlinearity of the problem.

The method of perturbations is applied (first utilized for the analysis of hypercritical deformation of a rectangular plate by P. Ya. Polubarinova-Kochina: *Prikl. Mat. Mekh.* **3**, 1, 16–22, 1936).

$$\mathcal{D}\,\nabla^4 w + kw - \frac{h}{r}\frac{d}{dr}\left(\frac{dw}{dr}\cdot\frac{dF_0}{dr}\right) = \nu q - \nu A(w) + \frac{b}{r}\frac{d}{dr}\left[\frac{dw}{dr}\cdot\frac{d(\Phi + \nu F_1)}{dr}\right] \qquad [1]$$

$$\nabla^4 \Phi = -E\,\frac{\nu}{r}\cdot\frac{dw}{dr}\cdot\frac{d^2 w}{dr^2} \qquad [2]$$

In the above, w = bending distortion, r current radius, q intensity of transverse loading, b thickness of plate, ν minor pa-

rameter. The solution of this system of equations, is sought in the form

$$w = \sum_{b=0}^{\infty} w_b \nu^k; \quad \Phi = \sum_{b=0}^{\infty} \Phi_b \nu^k$$

In the zero approximation ($\nu = 9$), $\Phi \equiv 0$ and Eq. [1] becomes linear; from it, the critical value of the force T_i and the function F_0 are determined. The bending function w_0 is in this case found with an accuracy to a particular multiplier $w_0 = K a_0 (r)$; where $a_0 (r)$ = the first proper function of the particular problem. The multiplier k is found by successive approximation by a method closely resembling that of Bubnov and Galerkin.

An example is investigated of a hinge-supported circular plate under the simultaneous action of radial forces and a transverse load, and in the presence of all elastic support with the reaction $R = lw^3$. The stability of different forms of equilibrium of the plate is examined. A. S. Vol'mir

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

1188. Nishiguchi, K., The creep deformation of the vibrational shell of the magnetic receiver, Proc. Sixth Japan nat. Congr. appl. Mech., Univ. of Kyoto, Japan, Oct. 1956, 531-534.

The (buckling) instability of a magnetic receiver-vibration shell can be caused by creep deformation. Investigating a model case, author finds few discrepances between analytical and experimental results. This is explained by variable stress distribution in particular (different shaped) parts of the shell in the course of creep advancement. The paper is considered a valuable design reference. F. Eisele, Germany

1189. Rogitsky, S. A., The stability of bar frames with fixed joints (in Russian), *Trudu' Uralsk. politekhn. in-ta* no. 54, 5-22, 1955; *Ref. Zh. Mekh.* no. 11, 1956, Rev. 7879.

The method described of verifying the stability of bar frames represents a combination of the method of displacements and the method of distributed constraining moments. It is assumed that the system is loaded only at the joints, only the bending deflections are considered, and the value of the normal forces at the instant of loss of stability is assumed not to change.

Examples of calculation are given. E. I. Silkin

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

Joints and Joining Methods

(See Rev. 1189)

Structures

(See also Revs. 1088, 1162, 1184, 1406, 1414, 1415)

1190. Klein, B., A simple method of matric structural analysis: Part II-Effects of taper and consideration of curvature, *J. aero. Sci.* **24,** 11, 813-820, Nov. 1957.

Paper continues the analysis of part I [AMR **10,** Rev. 3616] and extends the method to tapered aircraft structures and systems containing curved elements. In the former case, author makes the standard assumption of panels carrying only shear, but includes also the effects of a tapered sheet. All final equations of equilibrium and compatibility of the idealized structure are written down, and the final equations include, hence, both forces and displacements as unknowns. Thus equations arise with a high number of unknowns, and the relevant comments made in the review of part I apply here again. Strictly speaking, the proposed method is not a matrix analysis since, by common usage, this nomenclature applies now to procedures building up the final equations by matrix assembly methods. The part of the paper dealing with curved elements should be of particular interest to aircraft analysts. J. H. Argyris, England

1191. Langefors, B., Algebraic methods for the numerical analysis of built-up systems, *SAAB Aircr. Co. Linköping, TN* 38, 55 pp., 1957.

Author starts out with the premise that an elastic structure can not be treated by the concepts of a complex (or network) in algebraic topology, like an electrical network can. Instead the author replaces the physics of combinatorial topology by the algebra of linear vector spaces. To an electrical engineer, a beam with different forces at its two end-points suggests a two-winding transformer or a transmission line, whose topological analogue—a T or π network—has been known and put to practical use for over a half-century. Author does not follow such an "electrical" approach, but prefers to establish a set of theorems, lemmas and proofs for some abstract mathematical entities called links, having various orders of degeneracy. The latter are then identified with parts of the elastic structure. In spite of the algebraization, there is still much topology left in the paper, as suggested by the frequent use of nodes and pseudonodes. The transference and cotransference matrices introduced are reminiscent of the transfer tensors λ_1^2 and λ_2^1 (or leakage coefficients of a transformer) without assigning to them, however, any laws of transformation. As author himself states, the treatment is a step away from topology and tensors, and back to the conventional intuitive approach and to matrices. Accordingly, no traces of the connection tensor can be found that would show the manner of interconnection of the component links into a resultant network. New contributions for the analysis of stiffened-shell structures of statics are also given, as well as a formula for computing the redundancy of such structures. G. Kron, USA

1192. Nelson, H. M., Wright, D. T., and Dolphin, J. W., Demonstrations of plastic behavior of steel frames, *Proc. Amer. Soc. civ. Engrs.* **83,** EM 4, (*J. Engng. Mech. Div.*), Pap. 1390, 38 pp., Oct. 1957.

Paper reports tests on beams, small frames, knees and full-scale gabled frames which demonstrate essential validity of plastic analysis for welded steel structures fabricated from standard rolled sections. Tests were similar to those previously made by others [AMR **10,** Rev. 4012].

J. E. Goldberg, USA

1193. McClellan, R. E., Lateral deflections and stresses in building frames, *Proc. Amer. Soc. civ. Engrs.* **83,** ST 5 (*J. Struct. Div.*), Pap. 1354, 19 pp., Sept. 1957.

Author presents an approximate method suitable for the determination of deflections and stresses caused by lateral loads. The new method is based, in addition to the usual assumptions of the frame analysis methods, on the following two further suppositions: (1) The structural properties of corresponding elements in any two neighboring stories may be considered as identical; (2) the points of inflection of all columns are at their middle height. The lateral deflections are composed of two parts. In the first part, the deflection of the girders; in the second one, the columns are regarded as rigid. The formulas of the new method are deduced for symmetrical four-columned building frames, but the same procedure could be applied with some modification for the analysis of other building frames, too. As a numerical example, the classical Wilson-Maney bent is dealt with. The resulting values differ by not more then 10-20% from the exact values obtained by the slope-deflection method. The errors are approximately of the same

size as from the approximate slope-deflection method or the cantilever method. Though these errors are considerable, objections should not be raised against them, since the so-called exact methods are not accurate either. The so-called exact methods ignore the changes in the length of the columns and the stiffening effects of walls and floor slabs. In case of multistory buildings, these neglected effects could modify the results of the computations to a very considerable extent.

The presented approximate method allows for fast and simple carrying out of a tabulated computation, and so is a valuable help for practical purposes. P. Csonka, Hungary

1194. Cohen, E., Design of multi-guyed towers: Structural analysis, *Proc. Amer. Soc. civ. Engrs.* **83,** ST 5 (*J. Struct. Div.*), Pap. 1356, 30 pp., Sept. 1957.

The multi-level guyed tower is considered as an elastic supported beam. For that procedure it is necessary to know the spring constants of the elastic supports on the guy-levels. Though these are not constant values they may be considered as nearly constant within a short range around the working loads.

In the first step of the calculation the approximate values of the reaction forces are to be determined. In these computations, the tower is regarded as a continuous beam on rigid supports, and the calculation is carried out by moment distribution. Of course, the fixed-end moments, the stiffness factors, and the carry-over factors are taken into consideration with modified values. These values depend on the slenderness of the tower and the value of the axial force. In the second step the shaft is regarded as a beam supported on elastic supports. The loads applied are the opposite of the reactions determined in the previous step. The deflections caused by these forces on different levels are determined by the solution of linear simultaneous equations. In the computation, the secondary effects caused by wind are also taken into account.

The exact calculation of multi-level guyed towers is generally a very complicated problem. The simplifications introduced by the authors considerably facilitate the solution of the problem.

P. Csonka, Hungary

1195. Chinn, J., Pin-ended gabled frames, *Proc. Amer. Soc. civ. Engrs.* **83,** ST 5 (*J. Struct. Div.*), Pap. 1353, 13 pp., Sept. 1957.

Paper presents a method suitable for the calculation of one- or two-span, pin-ended gabled frames. The new method applies coefficients known from the moment-distribution method and formulas used in the slope-deflection method. As redundant quantities, the components of the reactions are introduced. The deflections due to the effects of unit forces are determined by the angle changes formed by the straight lines connecting joints. In case of one-span frames, the solution of the problem claims for the solving of one—in case of two-span frames of three—simultaneous equations. P. Csonka, Hungary

1196. Naruoka, M., and Yonezawa, H., On the design bending moment of highway beam bridge, Proc. Sixth Japan nat. Congr. appl. Mech., Univ. of Kyoto, Japan, Oct. 1956, 165–169.

Simplified approximate expressions for design moments in slab and beams of slab-and-beam highway bridges are based on analyses by theory of orthotropic plates. Different expressions are given for moments in edge and interior beam and for bridges with and without diaphragms or cross beams.

C. P. Siess, USA

1197. Zakharov, V. V., A method of graphical analysis for determining the optimum depth of steel bridge girders of variable cross-section (in Russian), Sb. tr. Mosk. inzh.-stroit. in-ta no. 10, 167–183, 1956; *Ref. Zh. Mekh.* no. 11, 1956, Rev. 7902.

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

1198. Chugaev, R. R., Design of the underground contour of dams on non-rocky soil (in Russian), *Izv. Vses. n. i. in-ta gidrotekhn.* **53,** 74–97, 1955; *Ref. Zh. Mekh.* 1956, Rev. 5301.

Using the methods of calculations of stability and strength of a dam and its foundation, author suggests determining a whole series of equally strong variants of the plant examined (equally strong as regards both the dam itself and its foundations).

A rational underground contour is determined by means of comparison of equally strong variants in respect of the efficiency of the dam, the simplicity and rapidity of production of the work, the possibility of using for construction of the dam personnel with corresponding qualifications and local building materials, and the simplicity of operating the plant.

Author examines the most difficult arrangements in principle of an underground contour of dams placed on non-rocky foundations and individual elements of the dams.

The filtration calculation of the given underground contour should be made according to the modified fragment method of N. N. Pavlovsky.

Fragmentation of the region of motion of soil waters is made not by verticals issuing from the edges of grooves (as in the case of N. N. Pavlovsky) but according to certain curved lines of equal pressure drawn from all the points of discontinuity of the underground contour. The pressure for the internal elements of fragment is unknown, for which reason the assumption is introduced that, on the internal sections of the fragments, the pressure varies according to a linear law.

There is no estimate of the degree of error of this method or comparison with accurate solutions.

P. F. Fil'chakov

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

1199. Kalinin, V. S., Investigation on deck flooring after loss of its stability (in Russian), *Trudi Vses. nauch. inzh. tekhn. o-va sudostr.* **6,** 2, 49–65, 1955; *Ref. Zh. Mekh.* 1956, Rev. 6149.

The service given by a deck surface was investigated after it had lost its stability due to continuous compression. Consideration is taken of the increase in number of waves of the elastic surface in proportion to the increase of load. It is assumed that the structure below the deck does not lose its stability and does not show resistance to buckling, while the deck surface can move freely along the ribs. The study is applied to the investigation of a separate plane half-wave, which has lost its stability, under the same boundary conditions. The number of half waves corresponding to the given average compressional stress is found by a comparison of the values of the reduction coefficients, calculated on the assumption that the elastic surface of the plane is composed of $m + i$ or $m + i + 1$ half waves, where m is the number of half waves determinable from the solution of the linear problem.

The equations of the nonlinear theory of the planes, recorded for the separate plane half-wave, are solved by the method of successive approximations.

In the first approximation the sagging is taken to be one half wave of a sinusoid in both directions. Numerical results are obtained in the second approximation. It is shown that an increase in the number of half waves decreases the resistance of the plane to compression.

Curves are presented of the reduction coefficients for the planes with different relationships laterally.

M. S. Kornishin

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

1200. Courbon, J., and Lacroix, R., Calculation of the network of crossed beams (in French), *Ann. Ponts Chauss.* **127,** 3, 271–318, May-June 1957.

A method is proposed for calculation of deflections and reactions of beams in an orthogonal network. The problem is reduced to that of continuous beams on elastic supports for different values of the elasticity coefficients of the supports. The applied loads are imagined to be decomposed into a linear combination called "characteristic loads" which have the property: under the effect of the characteristic loads the beams of one of the systems of the network are proportionately distorted.

Several examples of the application of the theory are given.

From authors' summary by W. H. Hoppmann, II, USA

1201. Vorobcius, O., Simplified method for erecting heavy precast arches in reinforced concrete to be used for arch bridges (in Rumanian), *Indust. constr. Mater. constr.* **8**, 9, 483–495, 1957.

Various methods of erecting precast and prestressed arched members are described and illustrated, to be used especially for hinged arches, shell-type bridges of the Maillart system, and arch bridges with suspended deck structure. Methods are demonstrated by actual examples of three-hinge arches spanning 164 ft. Structural elements weighing up to 100 tons were erected with typical cranes and trolley-mounted wood-frame towers. Additional reinforcing is to be provided for temporary stresses produced during erection. J. J. Polivka, USA

1202. Maracine, B., Prefabrication plant in Sophia for reinforced concrete "Vibrobeton" members (in Rumanian), *Indust. constr. Mater. constr.* **8**, 9, 509–519, 1957.

Thorough description of a large factory with all mechanical equipment, different types of structural members, pipes, piles, etc., methods of fabrication, their economy, and statistics concerning efficiency and production. J. J. Polivka, USA

1203. Derkach, V. F., Some matters regarding the evaluation of concrete structures when calculating prolonged processes (in Russian), *Trudi Khar'kovsk. inzh.-stroit. in-ta* no. 4, 155–166, 1955; *Ref. Zh. Mekh.* 1956, Rev. 6292.

An examination is made of the adaptation of the method of force to determine the stresses in ferro-concrete constructions, in the presence of creep and shrinkage of the concrete. Author makes use of the theory of aging and the linear connection between the deformation and the stressing. The shrinkage is taken to be proportional to the measure of creep. For the determination of displacement use is made of the principle of possible displacements. The influence of the shrinkage on pillar-support is analyzed. Numerical examples are given of the calculation for arches with closed abutments. Author's views regarding the influence of shrinkage have not been given in sufficient detail. There are cases of inaccurate formulation; some data which the author makes use of in the numerical examples are omitted.

P. I. Vasil'ev

Courtesy Referativnyi Zhurnal, USSR

Translation, courtesy Ministry of Supply, England.

1204. Mattock, A. H., Design and construction of a helical staircase, *Concr. constr. Engng.* **52**, 3, 99–105, Mar. 1957.

1205. Bauersfeld, W., Projection planetarium and shell construction, Instn. mech. Engrs., Prepr., 8 pp., 1957.

Rheology (Plastic, Viscoplastic Flow)

(See also Revs. 1138, 1149, 1150, 1179, 1183, 1188, 1234, 1307, 1412, 1413)

1206. Salvadori, M. G., and Weidlinger, P., On the dynamic strength of rigid-plastic beams under blast loads, *Proc. Amer. Soc. civ. Engrs.* **83,** EM 4 (*J. Engng. Mech.*), Pap. 1389, 35 pp., Oct. 1957.

The dynamic strength of simply supported beams acted upon by a uniformly distributed, suddenly applied load is found neglecting elastic deformations. If the criterion of strength is based on allowable plastic strains, the result is conservative so long as the deformation time is large compared to the natural periods of the beam. Both bending and shear deformations are considered. The load is assumed to vary in time according to a negative exponential function with the peak value at time $t = 0$. Buckling is assumed to be prevented by bracing. The range of pressures for which the analysis is valid is limited by the assumption of a single plastic hinge, but it can be extended to other types of beam supports and other types of impulsive loads.

A. D. Topping, USA

1207. Lee, S. L., and Ballesteros, P., Ultimate strength of short struts, *Proc. Amer. Soc. civ. Engrs.* **83,** ST 5 (*J. Struct. Div.*), Pap. 1358, 18 pp., Sept. 1957.

Ultimate strength is assumed in this paper to be the limiting load which is approached as the elastic area of the cross section approaches zero. Non-strain-hardening material having a bilinear stress-strain curve and identical stress-strain relationships in tension and compression is assumed. In addition to eccentric loading, pure unsymmetrical bending is considered.

The chief difficulty in the problem is the location of the neutral axis. Authors' approach is to assume any reasonable position for it and then to make translational and rotational corrections by a trial procedure. Authors say three trials ordinarily yield sufficient accuracy. Numerical examples are given.

A. D. Topping, USA

1208. Hodge, P. G., Jr., Plastic bending of an annular plate, *J. Math. Phys.* **36,** 2, 130–137, July 1957.

Complete solution is obtained for an infinite annular plate simply supported at the inner edge and subjected there to a prescribed moment. Material of plate is rigid-plastic, satisfies Tresca's yield condition and the associated flow rule, and hardens according to a linear isotropic law. The key to the solution obtained is that the complete stress and strain solution in each portion of the plate depends only upon conditions outboard of that region. Therefore, as each new region is formed at the edge of the hole, appropriate initial conditions are immediately available for integrating the flow laws.

From author's summary by H. Fernandez-Long, Argentina

1209. Mackenzie, J. D., High-temperature plasticity measurements in controllable atmospheres, *J. sci. Instrum.* **34,** 6, 246–247, June 1957.

1210. Lequear, H. A., and Lubahn, J. D., Certain departures from plastic ideality at small strains, *Trans. ASME* **79,** 1, 97–110, Jan. 1957.

1211. Olszak, W., Theory of plasticity of non-homogeneous bodies and its practical applications, Proceedings of the First Congress on Theoretical and Applied Mechanics, Nov. 1–2, 1955, 19–50, Kharagpur, Indian Inst. of Technology. $6.

Author resumes his previous papers (mainly in Polish language) on nonhomogeneity and anisotropy. Using series of elastic moduli (shear, volume expansion, Young and Poisson) and series of plastic moduli, author makes combinations of nonhomogeneity in one or two of the above-mentioned series, reaching different states similar to real bodies. Introducing a general yield condition he derives expression for the "reduced stress" in terms of octahedric shear stress and stress intensity. The theory is applied to plain problems, cylindrical and spherical shells, cylin-

ders with eccentric cross section, semiplane, limit analysis of plates, loose and cohesive granular bodies, etc.

L. Villena, Spain

1212. Thomas, T. Y., Slip surfaces in plastic solids, *Proc. nat. Acad. Sci. Wash.* **42,** 12, 923–927, Dec. 1956.

Author derives expression for direction of vanishingly small stress discontinuity in tensile specimen under plane stress conditions. Reviewer believes author must be unaware of AMR **7,** Rev. 1096 and Hill, R., "Mathematical theory of plasticity" (Oxford, Clarendon Press) 1950, p. 321, et seq.

J. F. W. Bishop, England

1213. Mura, T., Measurements of quenching stresses in rings, Proc. Sixth Japan nat. Congr. appl. Mech., Univ. of Kyoto, Japan, Oct. 1956, 111–115.

Residual stresses in bearing rings, due to quenching and shot blasting (with several grits and for several minutes), are measured by four types of experiments: (1) Radial cutting of the multiply-connected body of the ring (dislocation type). Shot blasting makes the sign of the residual stresses inverse, and the longer the blasting time, the more intense the residual stress. (2) By regarding the cut ring as a curved beam, the residual stresses of incompatibility type are obtained by measurements of changes of the inner radius due to successive removals of outer layers. The residual compression stress is intensified by shot blasting. (3) Sachs' method shows that the tangential stresses are greater than the radial stresses, and the compression stresses at the outer surface due to quenching become tension by shotting. (4) By the method of Newton's rings it is shown that the residual stresses fluctuate considerably from their mean values along the axial direction of the ring.

G. Sonntag, Germany

Book—1214. Creep and fracture of metals at high temperatures (Proc. of symposium held at Nat. Phys. Lab. May-June 1954), London, Her Majesty's Stationary Office, 1956, 420 pp. $5.60.

Twenty-two papers by experts cover progress made between 1946 and 1954. Subject is divided into four sections: Deformation processes in simple materials, Creep resistance of complex materials, Theory of fracture, Work on tertiary creep and fracture. Titles and authors are: "Introductory paper" (N. P. Allen); "A discussion of some models of the rate-determining process in creep" (N. F. Mott); "Plastic deformation of aluminium single crystals at elevated temperatures" (R. D. Johnson, A. P. Young, A. D. Schwope); "Mechanism of grain boundary displacement and its relation to the creep process as a whole" (F. N. Rhines); "Creep processes" (W. A. Wood); "Interaction between crystal slip and grain boundary sliding during creep" (D. McLean); "Some fundamental experiments on high-temperature creep" (J. E. Dorn); "Creep and ageing effects in solid solutions" (A. H. Cottrell); "Microstructure and creep" (J. W. Freeman and C. L. Corey); "The effect of alloying on the creep of metals" (L. Rotherham and C. R. Tottle); "Basic principles of a creep-resisting alloy" (A. Constant and C. Delbart); "Creep of solid solutions and compounds in metallic systems" (I. I. Kornilov); "The effect of changing loads during creep" (Y. N. Rabotnov); "An approach to the problem of intercrystalline fracture (R. Eborall); "Theory of accelerated creep and rupture" (C. Crussard and J. Friedel); "A theory of brittle and ductile fracture, with application to creep fracture, "based on the dynamic behavior of dislocations and condensation of vacancies" (A. Kochendorfer); "Observations on third-stage creep and fracture" (H. M. Jenkins); "Tertiary creep of nimonic 80A" (W. Betteridge); "Grain boundary participation in creep deformation and fracture" (N. J. Grant); "Investigation into the development of intercrystalline fractures in various steels under triaxial stress" (W. Siegfried); "Note on the fracture under complex stress creep conditions of an 0.5%-molybdenum steel at 550° C and a commercially pure copper at 250° C"(A. E. Johnson and N. E. Frost); "The effect of a "V" notch on the tensile creep behavior of molybdenum-vanadium steel" (R. W. Ridley and H. J. Tapsell).

In general the papers show much progress in the analysis of creep phenomena through application of fundamental physical theories and concepts (rate-process theory, dislocation theory, etc.). The behavior of grain boundaries is further clarified by tests of bicrystals and by new analytical approaches. Notch effects and combined loading conditions are treated in the light of modern theories of plasticity. The collection of papers contains information and theories that can be used directly by designers (Dorn's paper is an example).

Interesting discussions follow each paper and are supplemented by joint discussions.

F. R. Shanley, USA

Failure, Mechanics of Solid State

(See Revs. 1214, 1306, 1428)

Material Test Techniques

(See Rev. 1209)

Mechanical Properties of Specific Materials

(See Revs. 1192, 1216, 1254)

Plasticity, Forming and Cutting

(See also Revs. 1115, 1188, 1401)

1215. Lubkin, J. L., A status report on research in the circular sawing of wood, Stamford, Conn., Central Research Laboratory, American Machine & Foundry Co., 1957, ii + 193 pp. + 2 appendixes + Ref.

The critical analysis of results of the collected researches of many investigators can often throw light upon facets of a subject which may not be complete in the reports of individual investigators, taken separately. This status report draws together the work of some fifty research workers in ten different countries, all bearing upon the fundamental relationships between tools, forces, and materials involved in the circular sawing of wood.

In this report Dr. Lubkin has analyzed experimental work on circular saw performance as a function of cutting edge velocity and feed per tooth. The information on the effect of cutting velocity on cutting force is of special interest. This effect is of greater importance in wood machining than in metal cutting, because of the relatively high cutting velocities normally used in the cutting of wood. He discusses the influence of blade diameter, thickness, orientation of work piece with respect to the saw, and width of the sawn material upon the feeding and cutting forces, and upon the quality of the sawn surfaces so obtained. Investigations revealing the effects of tooth geometry upon saw performance and stability are compared to determine the extent to which these studies support common conclusions. It would be difficult to outline the entire scope of this report in a brief review.

The research worker will find the comparison of different measuring techniques and their evaluation of much interest in guiding his work. The merits of various methods are examined and weaknesses are mentioned. While no panacea is presented, the values and limitations of various techniques are clearly indicated by this discussion. The research worker will also detect the unexplored areas where his attention may be profitably focussed in the planning of future work.

To the tool engineer and designer the collected information on tooth geometry and operating characteristics will prove a valuable addition to the published information on the circular sawing of wood.

Dr. Lubkin does not overlook the influences of wood anatomy and physical properties in his analyses. An appreciation of this aspect of the work material is of particular value. The fact that some investigators have failed to adequately define the work material, and in some cases the tools, has placed limitations upon the interpretation of their results and pointed clearly to the importance of including this information in wood-machining reports.

The report reflects a persistent search for information. Language barriers have been crossed in this effort. The search, study, and analysis of a large portion of the important research work in this field, covering a period of 25–30 years, deserves commendation. The value which has been added to the reference material by its assembly and the clear and readable presentation make this publication worthy of the attention of engineers and scientists, teachers and students, interested in the machining not only of wood but of other engineering materials.

R. J. Hoyle, Jr., USA

1216. Spencer, A. J. M., A review of recent literature on the mechanics of metal cutting, Brown Univ. TR 5, 20 pp. + 1 fig., Mar. 1957.

The purpose of this report is to summarize the present state of knowledge of the mechanical aspects of metal cutting. Summaries are presented of experimental and theoretical work on the classification of metal chips, the mechanics of continuous chip formation, three-dimensional cutting operations, discontinuous chip formation, the dimensional analysis of cutting operations, the effect of the cutting speed, size effects in metal cutting, and the hardness of metal chips.

From author's summary

1217. Schmidt, A. O., von Turkovich, B. F., Roubik, J. R., and Ham, I., Ceramic tool performance tests (Part II), ASME Semiann. Meet., San Francisco, Calif., June 1957. Pap. 57-SA-101, 16 pp. + bibliog. + captions + 4 tables + 25 figs.

The behavior of the cutting forces in relation to cutting speed for a steel-cutting-grade of carbide and a ceramic is evaluated. It is apparent from charts that the cutting forces are practically identical, with carbide exhibiting slightly larger forces at low cutting speeds. The chip-thickness ratio and chip-contact areas were measured and are shown graphically relative to cutting speed. The variations of the cutting force F_c with rake angle are shown as a series of curves having cutting speeds as the set parameter. From the same measurements additional information was derived, including graphs of the shear angle as a function of cutting speed and tabulations of coefficient of friction, shear stress, and shear strain.

Cutting temperatures for ceramic and carbide tools were determined analytically and plotted in relation to cutting speeds and rake angles.

The power consumption has also been measured and the energy, in terms of hp/cu in./min, was computed from force measurements to provide data on the actual power requirements for both carbide and ceramic tools in machining AISI 1015 steel.

From authors' summary

1218. Tobias, S. A., The chatter of lathe tools under orthogonal cutting conditions, ASME Semiann. Meet., Berkeley, Calif., Pap. 57-SA-19, 9 pp., June 1957.

A mathematical theory of the chatter of lathe tools is presented. Two types of chatter are distinguished depending on whether the chatter amplitudes fall in the direction of the tool shank or in the direction of the workpiece velocity. The physical causes of chatter taken into consideration are the chip-thickness-variation effect, the penetration effect, and the slope of the cutting-force against cutting-speed curve. The results of the mathematical theory are presented in the form of stability charts. With these, chatter arising during the first revolution of the workpiece and that occurring during subsequent revolutions are discussed. It is shown that the stability of the system is affected by the workpiece velocity, the workpiece material, the geometrical shape of the tool and the tool shank, and so on, and that under certain conditions, the chip-thickness variation may have a stabilizing influence. The paper deals only with the effect of the various parameters on the stability conditions and is not concerned with the problem which types of chatter do actually occur in practice.

From author's summary

1219. Jouty, R., Mechanics of metal cutting (in French), *Publ. sci. tech. Min. Air, France* no. 326, 94 pp., 1957.

Results of a study of the machining of metals is presented. The majority of these results were obtained with a dynamo-metric, two-part tool holder and resistance-wire strain gages, under as varied working conditions as possible. Although research is usually directed toward improvement of performance, such as precision and finish of machined surfaces, life of tools, output, author has searched for an understanding of events and has often sought to have the tool operate under conditions far removed from present practice.

The normal objective of machining is to obtain by metal removal a determined surface; the chips are a by-product, often dangerous, most often without value. Here the situation is exactly reversed: only the observation of chips alone enables us to explore the phenomena. Quality of surface, use of tools—considerations very important in practice—are of no consequence to the essential operation: formation and removal of chips. The formation of a chip does not reduce solely to the separation of a slice of material, as one peels a fruit, but the shearing deformation is very important. Although machine tools have been in use for more than a century, it is curious and deceiving that the preceding observation, based on the rapidly increasing number of scientific works, escapes the majority of technicians of machining.

The first chapters are devoted to equipment description as well as to recalling previous works, particularly the theory of Piispanen-Merchant. According to the latter, the orientation of the shear plane, noted by the angle g, obeys the relation: $2g = 90° + \alpha - \phi$, where α is the angle of attack and ϕ the angle of friction between the chip and the attack face of the tool. This relation, inexact in the machining of common metals is, to the contrary, well verified by the free-machining leaded brasses. Their behavior is that of an antifriction alloy, and one obtains a remarkably low and constant value for ϕ. Except in rare cases one finds that ϕ varies rapidly as a function of the attack angle. Based on the recent works of Bowden and Tabor in the field of solid friction, author concludes the impossibility of using the notion of an angle of friction in the case of seizure (as is the case here), and searches in this direction for an explanation of the failure of Piispanen's theory.

Two following chapters are devoted to thermal phenomena. These result from the work of deformation (strain energy) and from the work of friction forces. In machining at high speed (carbide tools), the attack face reaches elevated temperatures, but limited in all cases to the fusion point of the metal being worked. Thus are explained a number of pecularities for the use of carbide tools. This study also emphasizes the present interest in aluminum-oxide ceramic tools, whose use has been developed in striking fashion in the British countries. Last chapter is on vibration of tools—discussion of auto-instability of tools, very analogous to that in aircraft wings and turbine blades and which may be explained satisfactorily.

The above is a rather free translation of the summary. Although the work appeared to be of reasonably high stature and well-documented, this translator was unable to find justification for a number of statements. C. C. Osgood, USA

1220. Backer, W. R., and Krabacher, E. J., New techniques in metal-cutting research, *Trans. ASME* **78,** 7, 1497–1505, Oct. 1956.

Information on newly developed research techniques for studying the metal-cutting process is presented. Tool-wear and grinding-wheel-wear measurement methods are discussed, and techniques for research into the mechanism of those wear processes are described. New equipment for studies of the mechanics of machining processes, including force measurements and chip-formation analysis, is also described. Representative data are presented to show how research utilizing these techniques contributed to the knowledge of machining principles.

From authors' summary

1221. Neppiras, E. A., and Foskett, R. D., Ultrasonic machining I. Technique and equipment, *Philips Tech. Rev.* **18,** 11, 325–335, 1956–1957.

The technique of using high-frequency mechanical vibrations for machining brittle materials has assumed considerable importance in recent years. In this technique, a resonant electromechanical transducer is used to generate vibrations, at an ultrasonic frequency, which are transmitted to the drilling tool through a mechanical focussing device designed to provide a sufficiently intense vibration at the tool face. The actual cutting agent is an abrasive powder dispersed in a liquid.

The growing interest in this ultrasonic machining technique has made it necessary to obtain an accurate assessment of the potentialities of the method. The first part of this article deals with the fundamentals of the technique and describes some ultrasonic drilling machines developed at the Mullard Research Laboratories. The second part of the article, to appear shortly, gives an assessment of the technique in terms of cutting speeds, accuracy, and surface finish. From authors' summary

1222. Van Rooyen, G. T., and Backofen, W. A., Friction in cold rolling, *J. Iron Steel Inst. Lond.* **186,** 2, 235–245, June 1957.

Coefficient of friction μ between roll and aluminum strip was determined by using two coplanar pressure cells built into a roll under right angle to its axis. With one cell installed radially and the other obliquely to the first, it was possible to measure both the normal (σ) and tangential (τ) stress components along the contact arc. It was found that $\mu = \tau/\sigma$ varied along the contact length and that a nonslip region existed on both sides of the neutral plane where $\tau = 0$. The latter conclusion was supported by spacing measurements on a purposely stalled strip of originally equidistant markings made on its surface prior to rolling.

N. H. Polakowski, USA

Hydraulics; Cavitation; Transport

(See also 1198, 1271, 1319, 1434)

Book—1223. Debski, K., Continental hydrology, Pt. I. Hydrometry (in Polish), Warsaw, Panstwowy Instytut Hydrologiczno-Meteorologiczny, 1955, 403 pp.

Book is designed for hydrographers in field work and working out observation data. Contents: Gaging stations, equipment, observations, presentation of results. River surveys, sounding. Discharge measurement: methods—direct measurement, orifices, weirs, dilution methods. Current meters, floats. Discharge curve. Computation of runoff. Solid runoff observation. Underground water observations. Measurement of precipitation, evaporation and temperature. Several methods by author, previously published, are included. Bibliography shows over 100 titles, mostly Polish and Russian. S. Kolupaila, USA

1224. Iwagaki, U., Hydrodynamical study on critical tractive force (in Japanese), *Trans. Japan Soc. civ. Engrs.* no. 41, 1–21, Dec. 1956.

Paper deals both theoretically and experimentally with the mechanism of initiation of movement of sand on the river bed. The basic idea of the author's theory is to construct the equilibrium condition with respect to the forces, such as gravity force, fluid resistance, and the resistance resulting from pressure gradient, all of which act upon each spherical sand grain, the velocity fluctuation of flow being taken into account in order to evaluate these resistances. In the theory, the concept of the mixing length of turbulence, the minimum scale of eddies in turbulence theory, and the sheltering effect of other sand grains are also considered.

Thus a dimensionless function of critical tractive force similar to that given by Shields is obtained and is compared with the experimental results at various laboratories, including those obtained by the author with a small closed channel having a uniform and square cross section. T. Hayashi, Japan

1225. Berman, Ya. R., Impact of a wedge in cavitation flow, (in Russian), *Prikl. Mat. Mekh.* **20,** 3, 421–425, May–June 1956.

Paper presents a new solution of the free streamline flow past a symmetric wedge first worked out by Bobyleff in 1881. The potential is then applied to calculate the induced additional mass due to the wake. Comparison to linearized free surface solution shows that the wake effect increases somewhat with wedge angle.

L. Trilling, USA

1226. Di Ricco, G., Steady laminar flow in open channels (in Italian), *Rev. Catasto Ser. Tec. Erariali* **11,** 3, Mar. 1956.

The general determination of backwater curves on open channel flow at small Reynolds numbers is given and especially clarified in the cases of triangular and rectangular cross sections.

P. Franke, India

1227. Morris, H. M., Jr., Flow in rough conduits, *Trans. Amer. Soc. civ. Engrs.* **120,** 373–410, 1955.

Paper is based on the assumption that the loss of energy in turbulent flow is largely due to the formation of wakes behind each roughness element. Therefore the longitudinal spacing of the roughness elements is even more significant than their height. Three basic types of flow are considered, (1) isolated-roughness, (2) wake-interference, and (3) quasi-smooth (or skimming). Equations for each type are given. Friction factors are correlated with a "wall Reynolds number" which is the usual Reynolds number multiplied by $\lambda/^{8\cdot5}/r_0$ where λ is the longitudinal spacing. Agreement is shown with the experimental results of Bazin, Schlicting, Gibson, Streeter, Johnson, Harris, and others, as well as the author's own tests.

Reviewer believes that this is a very important paper which should be thoroughly studied by all working in this field. Objections raised by the discussers and the author's replies should be considered. Reviewer notes a numerical error in Eq. 17(b) where 1.75 should be 1.874. R. W. Powell, USA

1228. Filchakov, P. F., A simulation of circulation problems with breakaway of the streamlines (in Ukrainian), *Dopovidi' Akad. Nauk. USSR* no. 5, 440–443, 1955; *Ref. Zh. Mekh.* no. 11, 1956, Rev. 7434.

A method is described for modelling two-dimensional circulation problems with breakaway of the streamlines, by means of the EGDA integrator instrument using electrically-conductive paper as the medium. The form of the free jet is found by stepwise approximation.

The exposition is illustrated by an example having an analytical solution, in which the relative error of determination of the drag forces is of the order of 3.7%.

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

1229. Dzhimsheli, J. A., New forms of closed sections of unpressurized tunnels and conduits for water (in Russian), *Izv. Tbilissk. n. -n. in-ta sooruzb. i gidroenerg.* **8,** 171–174, 1955; *Ref. Zh. Mekh.* 1956, Rev. 5921.

It is proposed to use a section consisting of a trapezoid in the upper part, a round segment in the lower. The base of the trapezoid is in a horizontal plane and passes through the uppermost point of the periphery, while the lateral sides of the trapezoid are tangential to the periphery.

With this form of transverse section of the water-conduit its discharge grows with the depth, and the maximum discharge corresponds with the maximum fullness. All the hydraulic calculations are carried out by the customary means used for the calculation of open conduits with open transverse section.

P. G. Kiselev
Courtesy Referativnyi Zhurnal, USSR
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Incompressible Flow: Laminar; Viscous

(See also Revs. 1116, 1226, 1255, 1268, 1291, 1304, 1315, 1320, 1322, 1325, 1326, 1336, 1342, 1343, 1373, 1380, 1395, 1407, 1408, 1417, 1418, 1430, 1435)

Book—1230. Corcoran, W. H., Opfell, J. B., and Sage, B. H., Momentum transfer in fluids, New York, Academic Press Inc., 1956, xi + 394 pp. $9.

This book aims to be a comprehensive introduction into those fields of fluid mechanics which the authors believe are of special interest to chemical engineers. This means it is a combination of details on laminar and turbulent shear flow, boundary-layer flow, and statistical properties of turbulence. In seven chapters the book tries to give the basic equations and relations in general and for those examples frequently used in industrial practice; e.g., flow between flat plates and in circular pipes, along a flat plate, and about circular cylinders.

Chapters contents are: (I) Introduction to momentum transfer; (II) simple properties (temperature fluctuations, characteristic length, mixing length, eddy viscosity); (III) macroscopic characteristics of turbulent flow (similarity hypothesis, hypothesis of momentum transfer and vorticity transport); (IV) velocity distribution and friction factors for turbulent flow; (V) general equations of fluid motion, ending with Navier-Stokes equations in rectangular, cylindrical, and spherical coordinates, and a dimensionless form of these equations; (VI) statistical properties of turbulence as correlations, kinetic energy, spectrum and decay of turbulence, structure of turbulent shear-flow; (VII) boundary layer with 25 sections.

The last quarter of the book contains four appendices, especially an introduction to tensors and statistical theory of turbulence. This latter part is not in direct relation to the abovementioned material but, perhaps, with its systematical order, it is appropriate to introduce mathematical outsiders into this field. The whole book is thought of as an abstract for a special purpose from a modern viewpoint of fluid mechanics and, indeed, it could be that engineers will find this book useful for quick information about recent methods in this field.

F. W. Riegels, Germany

1231. Proudman, I., and Pearson, J. R. A., Expansions at small Reynolds numbers for the flow past a sphere and a circular cylinder, *J. Fluid Mech.* **2,** 3, 237–262, May 1957.

Paper concerns the problem of obtaining higher orders of approximations to the solution of flow past spheres and circular cylinders for small Reynolds numbers as an improvement and extension of the solutions of Stokes and Oseen. The technique involved was that of developing separate expansions of the stream function, one which satisfies the boundary condition at the surface of the sphere (or cylinder) and one which satisfies the condition of uniform flow at infinity. These are the Stokes and Oseen expansions respectively. The two expansions so obtained were subjected to a matching procedure yielding further boundary conditions for each expansion. The leading terms in the expansions were, respectively, those of the original Stokes and Oseen solutions. Results are given in terms of the drag coefficient to higher-order approximation for the sphere.

R. M. Drake, Jr., USA

1232. Mabey, D. G., Slow viscous flow within circular cylinders, *J. roy. aero. Soc.* **61,** 556, 281–283, Apr. 1957.

Problem considered is a viscous fluid inside a sector of a stationary cylinder and a close fitting rotating cylinder. This is equivalent to a single cylinder with a stationary wall over part of the circumference and a uniformly moving wall over the rest of the circumference.

A mathematical solution is obtained for low Reynolds numbers where the stream function satisfies the biharmonic equation. A boundary-layer approximation for high Reynolds number has been given by H. B. Squire [AMR **9,** Rev. 3304].

Flow-visualization experiments are described which agree satisfactorily with the present theory for Reynolds numbers below 17 and with Squire's solution for Reynolds number 1.6×10^5.

W. Squire, USA

1233. Gersten, K., Influence of entrance velocity distribution on the secondary flow in cascades of compressor and turbine blades (in German), *Forsch. Geb. Ing.-Wes.* **23,** 3, 95–101, Feb. 1957.

"Secondary" here refers to a rotary or cross flow, resulting from wall or end effects, which, when superposed on a basically plane flow, produces three-dimensional effects in a blade cascade. Although some theoretical analyses of this phenomenon have been published, experimental data have been scarce. This article reviews some of the theoretical predictions, but is mostly concerned with presentation of test results. Perhaps the most striking conclusions are (1) that nonuniformity may have a large effect in a compressor cascade (because of the build-up of boundary layer) but a very small effect in a turbine cascade, (2) that after a certain thickness of boundary layer is reached, further increase does not appreciably increase the losses in either type of cascade.

Reviewer believes that a great deal more experimental data will be needed to give a complete picture, but that the data given here are interesting and a useful addition to the existing stock of knowledge. Eventually such articles should also devote more attention to helping the designer by indicating practicable means of reducing the losses resulting from secondary flow.

C. W. Smith, USA

1234. Stone, D. E., On non-existence of rectilinear motion in plastic solids and non-Newtonian fluids, *Quart. appl. Math.* **15,** 3, 257–262, Oct. 1957.

Author obtains results in agreement with Ericksen's findings [AMR **10,** Rev. 1412] for a class of ideal materials in which the stress is unaffected by a uniform change of the rate of deformation. It should be noted that, in this case, functions F_1 and F_2 appearing in Reiner's equation [4] [AMR **4,** 202–204, 1951] do not define material parameters and the material is not what has been named

the Reiner-Rivlin fluid, but an ideal plastic solid with tensorial nonlinearity, an interesting generalization of the Saint-Venant-Prandtl-Reuss solid. M. Reiner, Israel

1235. Rao, S. K. L., Harmonic analysis of the spatial flow of an incompressible viscous fluid, *Proc. Indian Acad. Sci. (A)* **44,** 1, 6–14, July 1956.

Author extends to three-dimensional space the method introduced by the reviewer for the two-dimensional flow of an incompressible viscous fluid; the Fourier transforms of the Navier-Stokes equations are given, first when the viscous fluid is contained in a bounded domain with velocity vanishing at the boundary, and next when the flow region is the entire space, the velocity vanishing sufficiently strongly at infinity. Bounds are given for the spectral function of the kinetic energy of the flow. The integrodifferential equations for the components of the velocity are integrated in the particular case when the nonlinear terms are negligible.

J. Kampe de Feriet, France

1236. Belotserkovskii, S. M., Ring vortex in unsteady flow (in Russian), *Prikl. Mat. Mekh.* **20,** 2, 173–183, Mar.–Apr. 1956.

Paper studies theoretically the velocity field set up by a bound vortex ring, whose strength varies round the ring and varies with time, together with the associated free vortices. The latter comprise line vortices, arising from space variations, and ring vortices, arising from time variations of bound vortex. Free vortices are assumed to be swept downstream at a uniform constant axial velocity; this assumption constitutes, in reviewer's opinion, a tacit approximation.

Special cases studied include steady flow in general, the well-known uniform constant bound vortex ring, and harmonic dependence upon time and azimuthal angle, both separately and together. Some of the velocity functions are tabulated for points lying on the vortex sheet.

Reviewer accepts claim that this is a useful extension of an existing method in incompressible inviscid aerodynamics research.

A. H. Armstrong, England

1237. Kochin, N. E., One existence theorem in hydrodynamics (in Russian), *Prikl. Mat. Mekh.* **20,** 2, 153–172, Mar.–Apr. 1956.

Posthumous publication of a previously incomplete work by the outstanding Russian hydrodynamicist who died in 1944. Work was completed by D. E. Dolidze and concerns existence theorems for an ideal incompressible homogeneous or inhomogeneous fluid flowing through a certain fixed region, under the action of potential forces. M. D. Friedman, USA

1238. Priem, R. J., Breakup of water drops and sprays with a shock wave, *Jet Propulsion* **27,** 10, 1084–1087, 1093, Oct. 1957.

An apparatus for investigating the effect of shock waves on sprays is described and illustrated. Shock strengths of 1.32 (Mach number 1.13) were obtained in a test section at one atmosphere. High-speed pictures of 0.030 to 0.160-in. diam water drops show that the drops are broken up by the high-velocity gas behind a shock front. Small water jets were not affected by a shock wave. Photographs of impinging jets, parallel sheets, and parallel jet types of sprays also show that the breakup of sprays is accomplished by the high-velocity gas behind the shock front. The shock tube has two parts: (a) the "shock development" part is 4 ft long and 5 in. square; to this are adjoining the (b) four "detonation tubes" of ¾-in. diam; by this means, four shocks can be produced at specific intervals. The jets are produced by gas-pressurized water tanks. Pictures of sprays were obtained with a "Fastex" camera using shadowgraph technique. Shock velocities were measured with two piezoelectric pickups placed 12 in. apart and connected to an oscilloscope; time required for the shock to travel between pickups was measured from the film record of the oscilloscope trace. A large number of pictures of drops and jets are shown, and the critical diameters of drops and jets below which no breakup occurs are shown in graphs.

K. J. De Juhasz, Germany

1239. Dombrowski, N., Eisenklam, P., and Fraser, R. P., Flow and disintegration of thin sheets of visco-elastic fuels, *J. Inst. Fuel* **30,** 198, 399–406, July 1957.

Viscoelastic hydrocarbon gels have very high resistance to disintegration. The maintenance of flame along the jet of fuel depends upon the generation of a combustible mixture and, thus, on the rate of vapor release. This, in turn, depends upon the rate of development of new surface, which is controlled by the manner of disintegration of the fuel. Gels of very low, up to very high, consistency have been discharged through single-hole, fan-spray nozzles to form sheets, for comparison with the disintegration of normal liquids. Whereas normal liquids yield droplets at disintegration, the sheets of viscoelastic gels may disintegrate into threads and not drops. For normal liquids, ejected into an atmosphere of reduced density, the laminar sheet becomes placid and the mode of disintegration changes. With a sheet of gasoline, normally ignited, the ignition zone is in front of the zone of disintegration and the flame has no effect on the manner of disintegration. If, however, the sheet is surrounded by flame it becomes placid and the mode of disintegration changes because the local conditions are equivalent to sub-atmospheric density. This is important for the disintegration of fuel by pressure nozzles in combustion chambers. Nozzles and spraying apparatus are described and illustrated; photographic equipment described. Charts are given for pressure versus velocity, pressure loss in nozzle versus pressure, coefficient of discharge versus pressure, and versus consistency. Photographs show disintegration of sheets into filaments and into droplets, both as ignited and as not ignited. K. J. De Juhasz, Germany

1240. Isler, D. A., and Thornton, D. G., Effect of atomization on airplane spray patterns, *Agricultural Engng.* **36,** 9, 600–604, Sept. 1955.

A comparison is made of the effects of three degrees of atomization (300, 150, and 80 microns median diam) on deposit patterns of sprays released from a Stearman airplane flown 50 ft above the ground. Results show that, with upwind tests, coarse atomization resulted in the narrowest swath, least uniform distribution across the swath, and excessively high deposit peaks. Although the fine spray gave a slightly wider and more uniform swath than the medium one, this advantage was cancelled by the higher loss of fine spray. Authors conclude that a spray of medium atomization (150 microns median diam) provides the most efficient swath pattern for forest spraying.

Airplane was rigged with a tubular boom along the span, with nozzles evenly distributed along the boom; liquid was distributed at rate of one gal per acre, over a 132-ft swath, at 80 mph. Atomization was determined by a photographic method. Spray distribution across the swath was determined from spray samples collected on each of two 6-×-6-in. aluminum plates located at 5-ft intervals on a line at right angles to the line of flight.

K. J. De Juhasz, Germany

1241. Chamberlin, J. C., Getzendaner, C. W., Hessig, H. H., and Young, V. D., Studies of airplane spray-deposit patterns at low flight levels, U. S. Dept. Agric., Agric. Engng. Res. Branch, Tech. Bull. 1110, 45 pp. + 29 figs. + 5 ref., May 1955.

Study of spray-deposit patterns of insecticide and pest control media from a low-flying airplane, fitted with an underwing boom carrying evenly placed spraying nozzles, concerns: (a) patterns of spray from individual 1-ft segments of underwing and tail booms with respect to aerodynamic forces that affect them; (b) effect of

spray atomization on the consistency of deposit rates, especially in the zone affected by the propeller vortex; (c) arrangement of nozzles, both with regard to atomization and spacing, required for optimum pattern and swath width.

A carmine dye was used as a tracer in the sprays; the spray deposits were collected on stainless-steel plates and measured by colorimetric analyses. Movies were taken during application to show development of spray curtain as it was affected by air currents generated by the airplane flight. Effective swath widths were determined by practical field tests on insect control. It was found that even though the spray is discharged in equal amounts from evenly spaced nozzles, yet aerodynamic forces greatly influence the deposits from foot to foot, both across and along the line of flight. At low flight levels the spray is spread laterally over a swath from 20 to 50 ft wider than the boom, depending on the height of flight, the fineness of the spray, and the presence of surface winds. The deposit pattern within the propeller slipstream zone is erratic.

Improvement in mean spray-deposit rates across a treated swath may be obtained from asymmetrical nozzle arrangements, the use of finer sprays inboard than outboard, and by using moderate rather than low flight levels. K. J. De Juhasz, Germany

1242. Kolmogorov, A. N., The break-up of droplets in a turbulent stream (in Russian), *Doklady Akad. Nauk SSSR (N.S.)* **66,** 5, 825–828, 1949.

The problem is investigated when into a turbulent stream of liquid no. 1 (in the present experiments this is water) a fine filament of liquid no. 2 is introduced, having the same density, but a different viscosity, and a certain interfacial surface tension respective to liquid no. 1. When the two liquids mix, the filament of liquid no. 2 is first deformed into an ever-finer twisting and branching thread, then may break up into drops, which become smaller up to a certain limit. The upper and lower limits of the drop size are investigated by the use of dimensional analysis, utilizing the Reynolds and Weber numbers, and tentative formulas are set up. It is found that the law of distribution of velocities, as a function of distance around the drops, has a critical influence. The reasonings and derivations involve the concept of the "internal turbulence scale," which is not rigorously defined.
K. J. De Juhasz, Germany

1243. Kinderman, W. J., and Wales, E. W., Fluid flow through two orifices in series III-The parameters of metastable and stable flow of hot water, *Trans. ASME* **79,** 1, 183–190, Jan. 1957.

1244. Ehrich, F. F., Choking flow in curved ducts, *J. aero. Sci.* **24,** 4, 319–320, Apr. 1957.

1245. Evans, B. H., Natural air flow around buildings, *Texas Engng. Exp. Sta. Res. Rep.* 59, 15 pp., Mar. 1957.

1246. Wada, I., and Fukazawa, K., Aerodynamic research on the accelerating cascade, V, VI, *J. mech. Lab. Tokyo,* **2,** 2, 7–13, 1956.

Experimental data are reported on two-dimensional cascades in accelerating flow, a situation appropriate for turbine nozzle blading investigations. The profile shapes tested were seven airfoils based on NACA 0009 and one circular arc. Reynolds numbers up to 3×10^5 based on blade-chord length demonstrated at the highest Reynolds numbers data show the head loss through the cascade to reach approximately constant values. Graphical pressure distribution about blades and the variation in deflection angle and total head loss with inlet air direction are included. Limited results indicate most effective pitch-chord ratio to be about 0.8, and deviation angles of circular arc seem to differ from airfoil blade sections. Two additional articles on cascades are being translated. R. G. Folsom, USA

1247. Galkin, V. S., A particular solution of Boltzmann's kinetic equation (in Russian), *Prikl. Mat. Mekh.* **20,** 3, 445–446, May–June 1956.

Viscous flow of dilute gases is considered from the point of view of the rigorous kinetic theory, as based on Boltzmann's collision equation. It is assumed that the molecules interact with a repulsive potential which is proportional to the negative fourth power of the intermolecular distance ("Maxwell molecules"). The coefficient of viscosity is proportional to the absolute temperature. The kinetic theory provides a set of simultaneous linear differential equations, determining the change in time of the components of stress. Usually a solution is obtained on the assumption that the viscous stresses are small in comparison with the hydrostatic pressure. In this case, the relaxation time—by which the rate of damping of flow is determined—is proportional to the coefficient of viscosity, in accordance with the hydrodynamical equations of Navier and Stokes. Assuming that the viscous stresses are larger, author obtains a lengthy expression for the relaxation time which does not agree with conventional hydrodynamics.

While recognizing the fundamental significance of the result obtained, reviewer has some doubts whether conditions for its applicability can be realized in the laboratory or in practice.
R. Eisenschitz, England

1248. Cox, R. N., A cross-flow theory for the normal force on inclined bodies of revolution of large thickness ratio, *J. Fluid Mech.* **2,** 5, 446–448, July 1957.

The Munk-Jones crossflow theory for inclined slender bodies of revolution is modified and refined to serve for less slender bodies of revolution. The ambient velocity is replaced by the local axiswise component of the surface velocity for the non-inclined body. In some instances, this is practical and simple.
M. M. Munk, USA

1249. Jungclaus, G., Pressure distribution around tilted surfaces with approximation of wake boundaries (in German), *Z. Flugwiss.* **5,** 6, 172–177, June 1957.

This paper is actually a continuation of a treatment on velocity and pressure distribution around tilted or bent surfaces. The initial treatment concerned essentially a flow boundary of constant thickness while the present paper elaborates on flow boundary with gradual increase in thickness distribution, starting from the line of bend. Author derives a fine theoretical approach and presents tables and calculations of lift coefficients for such case. Some approximations of wake boundary configuration in case of flow separation are introduced together with lift losses and determination of tilt angle (or bend angle) magnitude. A table of integrals concludes this well-arranged and useful treatise. A number of useful references on the subject are quoted.
C. R. Bell, USA

1250. Hurley, D. G., and Skeat, P. R., A series of aerofoils designed to develop exceptionally large lift coefficients when boundary layer control by blowing is employed, *Aero. Res. Labs. Melbourne, Austral., Rep.* A. 102, 20 pp. + 2 tables + 17 figs., Mar. 1957.

Using classical mapping methods, authors set out to determine airfoil profiles consisting of two straight portions joined at the trailing edge and a nose whose shape is chosen so as to insure there, for a definite incidence, constant speed. For other than this design incidence, the speed will, of course, not be constant. It is found that the lift coefficients of the profiles are surprisingly high, but their shape is such as to cause flow separation along the upper straight portion. It is proposed to apply boundary-layer control to suppress separation. This, in fact, is the underlying purpose of the investigation whose aim was to determine high-lift profiles, their adverse pressure regions being located in a manner to make boundary-layer control feasible. Wind-tunnel tests with

one of the calculated profiles, and endowed with a blowing slot, are being prepared. A. von Baranoff, France

1251. Etkin, B., Aerodynamic transfer functions: an improvement on stability derivatives for unsteady flight, *Univ. Toronto Inst. Aerophys. Rep.* 42, 11 pp. + 5 figs., Oct. 1956.

Author shows some of the limitations of classical aerodynamic stability derivatives based on quasi-static analysis. Aerodynamic transfer functions are defined which may be regarded as generalizations of the classical derivatives. These transfer functions can readily be obtained either from the indicial admittances or the frequency response; two worked examples are given. It must be noted that the method is restricted to linearized systems.

No mention is made of earlier work by Temple [*British Aero. Res. Counc. Rep. Mem.* 2114] on this subject. Reviewer feels that paper emphasizes the need for further analysis of unsteady motions, especially lateral motions.

A. W. Babister, Scotland

1252. Stewart, H. J., and Ormsbee, A. I., Conical techniques for incompressible nonviscous flow, *J. aero. Sci.* **23,** 11, 1029–1036, Nov. 1956.

Authors give an interesting application of Donkin's conical solution of the Laplace equation, homogeneous of order zero, to subsonic aerodynamics. They discuss the properties of these solutions and show how under certain conditions their superposition can be used to obtain three-dimensional flow fields satisfying given boundary conditions. Source sheets of constant strength and finite area are used to construct the subsonic field of thin nonlifting polygonal planform wings (in particular swept wings). Wings of finite span and constant pressure distribution at small angles of attack can be represented by constant-strength vortex sheets. K. Pohlhausen, USA

1253. Zhukobsky, M. I., The determination of the exit angle of the flow through a profile cascade (in Russian), Inform. Communic. to Central Inst. of Steam Boilers and Turbines no. 143, 1955, 10 pp.; *Ref. Zh. Mekh.* no. 11, 1956, Rev. 7429.

A method is examined of determining the breakaway point and finding the angle of exit β_2 in the plane potential flow of an incompressible fluid through a cascade of profiles with rounded trailing edges. Some examples are given of turbine cascades with satisfactory coincidence of the analytical and experimental values of β_2.

The semiempirical methods used in practice for calculating β_2 are not mentioned. The possibility of divergence between the calculated and the experimental values of β_2 is explained by the author by the essential inaccuracy of the numerical transformations; but in reality, this divergence is to be explained by the fact that, in the flow model used, no allowance is made for breakaway of the flow at the trailing edges, nor are the influences of viscosity and compressibility of the gas taken into account. The well-known theoretical model with a wake region behind the trailing edges is more accurate. G. Yu. Stepanov

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

1254. Fantalov, L. I., and Rabinovich, A. V., The hydrodynamics of molten metals (in Russian), *Vestnik Akad. Nauk SSSR* no. 4, 95–99, 1955; *Ref. Zh. Mekh.* no. 11, 1956, Rev. 7137.

Authors discuss reports presented at a conference on "The hydrodynamics of molten metals" held 10–11 January, 1955 by the Mechanical Engineering Department of the Academy of Sciences of the USSR. The physical properties of the metals (viscosity, surface tension, etc.) are investigated; methods of measurement described, problems of metal flow in moulds and feeders examined; the calculation of gating and venting systems for steel and iron castings is demonstrated; the relationship between the properties of the metals in their liquid and solid states, the simulation of the process of metal flow, the use of radioactive isotopes in the investigation of mould-filling and feeding are discussed.

In the report by B. V. Rabinovich, "The subject and problems of the hydraulics of molten metals," the specific properties are discussed both of the liquid melts and of the walls of the passages formed in the moulding sand.

The flow of molten metals in the passages of a foundry mould represents a case of flow under a pressure head of a liquid of variable viscosity in "porous" (gas-permeable) pipes without filtration.

E. G. Shvidkovsky in a report on "The viscous properties of molten metals" investigates the structure of a metallic liquid, the relationship between structure and viscous properties, and some important applications of the principles of hydraulics and heat exchange.

The surface tension of melts is discussed in reports by A. Kh. Breger on: "The nature of the surface tension in molten metals;" V. K. Semenchenko: "The relationship between the properties of the liquid phase and the formation of the crystalline phase;" A. A. Klyachko and L. L. Kunin: "Results of surface-tension measurements on metals."

The flow of ferrous metals in channels is discussed by A. M. Korol'kov, A. P. Pronov, B. B. Golyayev, E. Z. Rabinovich and V. O. Yakovlev.

Problems of the melting, pouring, and crystallization of nonferrous metals are dealt with by G. I. Orlova, K. P. Milytsin, I. N. Friedländer, M. V. Sharov and A. Ya. Radin.

V. G. Gruzin reported on the temperature control of liquid steel by means of a new tungsten-molybdenum thermocouple. B. I. Medovar elucidated the relationship between the state diagram of the melt and the hot-shortness of austenitic steels.

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Compressible Flow, Gas Dynamics

(See also Revs. 1147, 1282, 1285, 1288, 1289, 1293, 1295, 1300, 1304, 1310, 1337, 1338, 1345, 1350)

1255. Dosanjh, D. S., Experiments on interaction between a traveling shock wave and a turbulent jet, *J. aero. Sci.* **24,** 11, 838–844, Nov. 1957.

To investigate interaction of a plane normal shock front traveling in a turbulent jet flow, different types of subsonic and supersonic jets were mounted either close to the open end or inside a shock tube, and the transient passage of the shock front through the turbulent flow was optically recorded by shadowgraphs. A few typical shadowgraphs are reproduced. As a result of its passage through the jet, the shock wave developed a bulge. The progressive increase of the transverse distance of the bulge was exploited to find the angle of spread of the subsonic jet exhausting into quiescent air. The depth of the bulge reduced in magnitude the farther downstream from the jet exit the shock front advanced. It is shown that beyond an equivalent distance of about twelve jet diameters, the bulge profile reaches a state of similarity.

When the jet is flowing against the direction of advance of the traveling shock front, an auxiliary wave system, which resembles an intense acoustic emission, originates. This acoustic radiation is of high frequency and intermittent, and is discussed in some detail. M. Morduchow, USA

1256. Baron, M. L., Response of nonlinearly supported spherical boundaries to shock waves, ASME Summer Conf., Berkeley, Calif., June 1957. Pap. 57-APM-12, 5 pp.

Author solves first the response problem of a spherical boundary to a step shock wave if the pressure-displacement relationship is

linear. The differential equation for the velocity potential is transformed with respect to time by a complex Fourier transform and for the fundamental mode, which has usually the major effect, the expression for the displacement-time response can be found explicitly. The response of the boundary to a linearly decaying shock wave is determined then by Duhamel's theorem. The displacement-time response of the boundary with a linear displacement-pressure relationship to a suddenly applied radially symmetric unit step pressure can be evaluated in the same manner. If the two displacement-time responses of the spherical cavity for the linear case are known, the nonlinear pressure-displacement relationship yields a nonlinear integral equation, which can be solved numerically. In a numerical example with rather unfavorable pressure-displacement characteristics, the numerical work was ample, but by the partial use of an inversed procedure it could be shortened somewhat. A. Kuhelj, Yugoslavia

1257. Jahn, R. G., Transition processes in shock wave interactions, *J. Fluid Mech.* **2,** 1, 33–48, Jan. 1957.

Shock-tube experiments on shock reflection from solid boundaries are known to agree with theory in range of regular reflection. However, observed reflection remains regular beyond theoretical limit of shock strength. Moreover, theoretical solutions for Mach reflection disagree badly with observations when incident shock is weak.

To elucidate these anomalies, experiments were performed on refraction of a shock through an air-methane interface. This technique makes region of anomaly more easily observable.

Refraction experiments exhibit anomalies similar to those for reflection from solid boundary. Interferograms show continuous subsonic rarefaction zone downstream of intersection point, with maximum intensity at intersection point.

Author suggests that, beyond shock strength where flow behind incident shock is exactly sonic, a subsonic singularity at the intersection point may account for the discrepancies between experiment and the simple theory. A. H. Shapiro, USA

1258. Krzywoblocki, M. Z. v., On the bounds of the thickness of a steady shock wave, *Appl. sci. Res. (A)* **6,** 5/6, 337-350, 1957.

Highly mathematical. Authur shows that taking into account all the Burnett terms in the solution of the Boltzmann transport equation does not significantly alter the value for the upper bound of the thickness of a steady shock. D. ter Haar, England

1259. Honda, M., Theory of the interaction between oblique shock waves and laminar boundary layers, *Rep. Inst. high Speed Mech., Tohoku Univ.* **8,** 109–130, 1957.

The theory of the interaction between a weak oblique shock wave and a laminar boundary layer due to Lighthill [*Proc. roy. Soc. Lond.* (A) **217,** p. 478, 1953] is used to calculate the resultant change in the skin friction. In particular, the strength of the incident shock necessary to produce separation is calculated. The agreement with experiment when the shock is induced by a convex corner is good, bearing in mind the limitations of the theory. Although not mentioned by the author the results have an application in the theory of the interaction between a *strong* shock and a laminar boundary layer. Let it be assumed that when the boundary layer separates, ahead of the shock, the main stream is turned through an angle θ such that pressure induced is just sufficient to provoke separation. Then, using Honda's results, a formula for the induced pressure is obtained of the same form as Gadd's [*J. aero. Sci.* **24,** p. 759, 1957]. K. Stewartson, England

1260. Tani, T., A method for solving the second-order problems of axially symmetric supersonic flow (in Japanese), *J. Japan Soc. aero. Engng.* **5,** 46, 306–308, Nov. 1957.

A reduced stream function ψ is defined so that it satisfies the continuity equation for slightly disturbed axisymmetric supersonic flow in which the higher-order terms than the third of the perturbation velocity components are neglected. The irrotationality condition yields a nonlinear partial differential equation for ψ. A few particular solutions of this equation are obtained in closed form which is shown to represent generalized conical expansions behind the Mach cone. R. Kawamura, Japan

1261. Gontier, G., Caragraph, an instrument for the graphical determination of supersonic flows with the help of the method of characteristics (in French), *Publ. sci. tech. Min. Air, France NT* 67, 24 pp., 1957.

This device can be applied to supersonic, irrotational, and two-dimensional flow problems for Mach numbers in the range of 1 to 7. Primary application is the construction of the flow field for a given velocity distribution along a straight line. In this connection a method for designing a two-dimensional supersonic tunnel is presented. S. Ostrach, USA

1262. Sugo, M., On the supersonic wing-body lift, Proc. Sixth Japan nat. Congr. appl. Mech., Univ. of Kyoto, Japan, Oct. 1956, 265–267.

Sugo considers the interference lift of the wing-body combination when the system is at angle of incidence. To find perturbation potential for the body, the well-known source-sink and doublet method is used. To cancel the downwash velocity on the wing by the body, Sugo applies a doublet distribution. The influence of a rectangular wing on the body is calculated by means of the constant strength doublet distribution on the wing, neglecting the terms of the second order. To cancel the influence of the normal velocity on the surface some additional line doublet along the body axis has to be added. The procedure is repeated for a sweptback wing. A comparison of the resulting lift increment by the downwash of the wing shows good agreement with the Ferrari results [*J. aero. Sci.* June 1948], and Cramer's experimental results [*J. aero. Sci.* Sept. 1951]. M. Z. v. Krzywoblocki, USA

1263. Kondo, J., Studies on the low-supersonic flow with a detached shock wave, Proc. Sixth Japan nat. Congr. appl. Mech., Univ. of Kyoto, Japan, Oct. 1956, 253–258.

Author develops variational method based on Hamilton's principle. Advantages of this method are listed, and it is applied to two-dimensional problems of flow with a detached shock about a circular cylinder; the distance of the detached shock from the cylinder is determined. D. ter Haar, England

1264. Takano, A., A method for calculating the interference zero-lift drag on a wing-body combination in the supersonic flow, Proc. Sixth Japan nat. Congr. appl Mech., Univ. of Kyoto, Japan, Oct. 1956, 259–263.

The purpose of the paper is to determine interference potential for the wing-body combination in supersonic linearized flow. The body is represented by source distribution (Karman-Moore's result is used) along the axis; the wing is replaced by source distribution in the wing plane (Puckett's solution is used). Potential consists of three parts: (1) body potential, (2) wing potential, (3) additional potential to (1) due to the wing (so-called interference potential). Boundary condition on (3) is that the radial velocity due to (3) must be equal and opposite to the radial velocity due to (2) on the surface of the body. Potential is defined for various parts of the wing (inside and outside forecone); the effect of the sweepback of the leading edge is also considered. Using the potential, Takano calculates the pressure coefficient in the usual way. The particular case refers to a rectangular wing mounted on the circular cylindrical body of infinite length. A comparison of the results with Nielsen's theory [*NACA Rep.* 1252, 1955] shows some difference to the disadvantage of the present theory.

M. Z. v.Krzywoblocki, USA

1265. Behrobohm, H. Lift cancellation and upwash cancellation, two dual techniques of the linearized supersonic airfoil theory. Application for the double delta wing, *Z. Flugwiss.* **4,** 8, 263–268, Aug. 1956.

The "lift-cancellation technique," based on linearized supersonic airfoil theory and repeatedly found in American literature, is confronted with an "up-wash cancellation technique." This method was applied to extensive systematic calculations of total lift and pitching moment for thin double delta wings in supersonic flow, with the position of the leading edge kink and the angles of sweep of the leading edge in front and aft of the kink as variable parameters. The method lends itself readily to calculations of local resultant pressure distribution over such wings.

From author's summary by P. F. Maeder, USA

1266. Tamaki, F., Studies on the hypersonic flow using a double-diaphragm shock tube, *J. phys. Soc. Japan* **12,** 5, 550–555, May 1957.

This paper describes a two-diaphragm shock tube equipped with a two-dimensional divergent nozzle capable of a Mach number of 6.4 for a period of about 1 millisecond. Pressure-distribution and flow-visualization data are given for three elliptic-nosed plates.

J. V. Becker, USA

1267. Hammitt, A. G., the hypersonic viscous effect on a flat plate with finite leading edge, WADC TN 57-105, vii + 14 pp. + 10 figs., Mar. 1957.

From author's previous experimental data on such plates in the Princeton Helium tunnel, he proposed a model for the flow downstream from the leading edge, that "...the viscous effects can be calculated as the difference between the inviscid flow about an effective body consisting of the actual body modified by the boundary-layer thickness and the inviscid flow about the actual body." The boundary-layer growth was solved by the momentum-integral approach with the measured pressure distribution at various Reynolds numbers, the leading edge thickness being used as the length scale. The "effective body" was taken as the flat plate plus the displacement thickness. The thus extrapolated "inviscid" pressure distributions "at infinite Reynolds number" fell on essentially a single curve and appeared to agree with the experimental distribution at the higher Reynolds numbers.

S. F. Shen, USA

Wave Motion in Fluids

(See also Rev. 1403)

1268. Reid, R. O., and Kajiura, K., On the damping of gravity waves over a permeable sea bed, *Trans. Amer. geophys. Un.* **38,** 5, 662–666, Oct. 1957.

Authors examine with a more rigorous approach the problem of damping of gravity waves over a permeable sea bed, already studied by Putnam. They consider a two-layer coupled system wherein the upper layer of mean depth h is an incompressible fluid, the lower being a porous medium of uniform permeability and infinite depth. They suppose that the pressure and velocity distributions in the upper layer are influenced by the percolation across the lower layer, the acceleration of the flow in this layer being not neglected.

The existence of a velocity potential in the upper layer is assumed, and a solution of the equations of the problem is given as a simple harmonic, exponentially damped wave. A specific example and graphs of the decay parameter and of the velocity distribution in the fluid are given.

G. Sestini, Italy

1269. Yamada, M., On the highest solitary wave, *Rep. Res. Inst. appl. Mech. Kyushu Univ.* **5,** 18, 53–67, 1957.

Paper considers the problem of the highest solitary wave in an infinite canal of finite depth, by the method of Levi-Civita and numerical and iterative procedure [see following review].

The numerical results are 4% different from the results of McCowan [*Phil. Mag.* (5) **32,** p. 45, 1891 and **38,** p. 351, 1894] and appear to fit better with the extrapolated experimental curve of the Hydrodynamical Laboratory of M.I.T. ["Coastal Engineering," vol. 3, div. 1, chap. 2, 1952].

J. M. Jackson, Scotland

1270. Yamada, H., Highest waves of permanent type on the surface of deep water, *Rep. Res. Inst. appl. Mech., Kyushu Univ.* **5,** 18, 37–52, 1957.

This paper adapts the method of Levi-Civita [*Math. Ann.* **93,** p. 264, 1953] to the problem of determining the highest waves of permanent type forming an infinite wave train on a canal of infinite depth.

The novelty of the author's method consists in commencing the numerical solution at an earlier stage than Mitchell and Havelock, [J. H. Mitchell, *Phil. Mag.* (5) **36,** p. 430, 1893 and T. H. Havelock, *Proc. roy. Soc.* (A) **95,** p. 38, 1919]. He also devises an interative method of calculation which can be carried out to any desired degree of accuracy. The author uses the residual in the equation expressing the fact that the pressure is constant on the free surface as a test of the completion of the iteration.

Numerical results are given of the ratio H/L for wave steepness; the value 0.1407 is obtained, compared with 0.1418 by Havelock.

J. M. Jackson, Scotland

1271. Adachi, S., On the propagation of flood waves in the transient region between the river channel and the storage region of reservoir, Proc. Sixth Japan nat. Congr. appl. Mech., Univ. of Kyoto, Japan. Oct. 1956. 367–371.

Model tests were performed with a flood wave in the Kiso River between two dams. Transition zone was investigated between a uniform channel, where celerity of propagation depends on the velocity of flow, and a reservoir, where the wave suddenly retards. The time of propagation through the reservoir can be obtained by usual storage computation methods.

S. Kolupaila, USA

1272. Prusseinov, A. S., An instance of the use of a perspective wave-meter according to R. N. Iavanov for sea-wave measurements in an inshore current (in Russian), *Meteorol. i. gidroligya* no. 2, 39–40, 1955; *Ref. Zh. Mekh.* no. 11, 1956, Rev. 7484.

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

1273. Tan, H. S., Waves produced by a pulsating source traveling beneath a free surface, *Quart. appl. Math.* **15,** 3, 249–255, Oct. 1957.

Author is unfortunate in having been forestalled by E. Becker, who treated a more general problem (finite depth) including this as a special case [AMR **9, Rev. 3301**].

The results of the two papers disagree. In reviewer's opinion, the entry in table I of the present paper for $J(\kappa_2)$, $0 < \tau < \frac{1}{4}$, is erroneous and should read $0-$ for $0+$. For a slowly moving source, or a slowly pulsating one, the two papers would then agree in finding one wave train propagating upstream and three downstream.

A. H. Armstrong, England

1274. Perotto, P. G., Propagation of pressure waves in a tube (in Italian), *Atti Accad. Sci. Torino Cl. Fis. Mat. Nat.* **89,** 101–111, 1954–1955.

Turbulence, Boundary Layer, etc.

(See also Rev. 1227, 1232, 1250, 1255, 1267, 1306, 1307, 1346, 1371, 1426, 1431)

1275. Uberoi, M. S., Equipartition of energy and local isotropy in turbulent flows, *J. appl. Phys.* **28,** 10, 1165–1170, Oct. 1957.

Paper is concerned with the tendency of turbulent motion to approach the isotropic state either generally or only so far as motions of small scale are concerned. Axisymmetric turbulence was produced by passing grid turbulence through the contraction of a wind tunnel, and the intensities of the velocity components and their spatial derivatives were measured. It was found (a) that the time required to re-establish equipartition of energy among the components was of the same order as the characteristic time for energy decay; (b) that the mean squares of the vorticity components became equal before equipartition of energy is established; (c) that the mean rate of deformation in the contraction leads to considerable anisotropy of the dissipating eddies, which disappears slowly in the parallel flow. Measurements of vorticity in a channel confirm this last result. The implications of the experimental results are fully discussed, and the limitations of the concept of local isotropy are discussed, for wall turbulence and for free turbulence. A. A. Townsend, England

1276. Grant, A. M., A corrected mixing-length theory of turbulent diffusion, *J. Meteor.* **14,** 4, 297–303, Aug. 1957.

Paper concerns the one-dimensional dispersion ($\overline{X^2}$) of a single fluid particle about its initial (given) position in a field of steady homogeneous turbulence, or, equivalently, with the dispersion of the distribution of mean concentration of some diffusing property released instantaneously in the form of a thin sheet in such a field. When simple mixing-length theory is applied to the problem in the latter form, it predicts a rate of transfer which is, as usual, proportional to the gradient of mean concentration, the eddy diffusivity being independent of time. This prediction cannot be reconciled with the known exact result that the dispersion $\overline{X^2}$ grows first as t^3 and later as t. The author is worried about this, although reviewer does not think that the originators of mixing-length theory would have contemplated applying it in the above circumstances.

The author succeeds in making the results of mixing-length theory compatible with exact diffusion analysis by supposing that the mixing-length for a migrating element of fluid is equal either to the customary constant value, or to the distance travelled by the element in the diffusion time t, whichever is the smaller.

G. K. Batchelor, England

1277. Phillips, O. M., The final period of decay of nonhomogeneous turbulence, *Proc. Camb. phil. Soc.* **52,** part 1, 135–151, 1956.

Author determines the final period of decay of nonhomogeneous turbulence produced by a localized disturbance to a fluid initially at rest. His solution depends on the net linear momentum imparted to the fluid in the disturbance, and, when this quantity is non-zero, the final motion takes the form of a vortex ring which exhibits important differences from the classical vortex ring in an irrotational fluid, in that its center is at rest relative to the fluid at large distances and its radius increases with time. He remarks that this type of motion can be observed when a smoke ring is blown into otherwise still air.

From the solution for a localized disturbance, author constructs the vorticity and velocity fields produced by disturbances distributed throughout a finite volume of the fluid and shows that the final period of *any* turbulent motion may be described in this manner: namely, by superposing elementary vortex ring solutions. In particular, he applies the argument to the flow in the turbulent wake of a body of revolution (for which a final period of decay is attained, in contrast to the two-dimensional wake where the Reynolds number is invariant with distance from the body) and finds that the motion consists of a turbulent motion whose energy per unit mass decays as the 7/2-power of the (large) distance from the body.

Reviewer considers this paper an elegant contribution to the theory of turbulence. P. R. Owen, England

1278. Ippen, A. T., and Raichlen, F., Turbulence in civil engineering: measurements in free surface streams, *Proc. Amer. Soc. civ. Engrs.* **83,** HY5 (*J. Hydr. Div.*), Pap. 1392, 28 pp., Oct. 1957.

Turbulence measurements in water, taken with a total-head-condenser-microphone velocity fluctuation gage, are reported. The use of the devices were limited to low frequencies (one gage had a natural frequency 15.4 cps, another 255 cps); therefore, turbulent intensities integral scales were measured but not microscales (dissipation length). L. S. G. Kovasznay, USA

1279. Robertson, J. M., Turbulence in civil engineering: an introduction to three research papers, *Proc. Amer. Soc. civ. Engrs.* **83,** HY5 (*J. HydroDiv.*), Pap. 1391, 6 pp., Oct. 1957.

Gives historical background and civil engineering motivation for turbulence research. L. S. G. Kovasznay, USA

1280. Robertson, J. M., and Calehuff, G. L., Turbulence in civil engineering; Turbulence in a diffuser boundary layer, *Proc. Amer. Soc. civ. Engrs.* **83,** HY 5 (*J. Hydr. Div.*), Pap. 1393, 20 pp., Oct. 1957.

Measurements of turbulence intensity at five stations and shear at one station in the boundary layer on the inside of a 7½ degree conical diffuser are reported. Comparison of the results with those reported for non-pressure gradient boundary layers indicates significant divergence from the universal inner region concept. The microscale of turbulence appears to be remarkably constant although other turbulence quantities are greatly increased as the flow develops in the adverse pressure gradient.

From authors' summary by L. S. G. Kovasznay, USA

1281. Grossman, L. M., Li, H., and Einstein, H. A., Turbulence in civil engineering: investigations in liquid shear flow by electromagnetic induction, *Proc. Amer. Soc. civ. Engrs.* **83,** HY 5 (*J. Hydr. Div.*), Pap. 1394, 16 pp., Oct. 1957.

The use of the electromagnetic flow meter to measure mean velocity and turbulent fluctuations in a turbulent pipe flow is discussed. At the present time the technique is limited to small pipe cross sections where sufficiently large external magnets can impose a magnetic field across the entire section. Authors suggest the use of small permanent magnet built into the probes.

L. S. G. Kovasznay, USA

1282. Crane, L. J., and Pack, D. C., The laminar and turbulent mixing of jets of compressible fluid. I: Flow far from the orifice, *J. Fluid Mech.* **2,** 5, 449–455, July 1957.

By using an eddy kinematic viscosity coefficient in turbulent flow it is possible to combine in one the equations for laminar and turbulent flow. An approximate solution is found by a method developed earlier by Pack [AMR **8,** Rev. 1068] for axially symmetric jets. Assumptions are: Prandtl number unity, viscosity varying as nth power of the absolute temperature, and stagnation temperature of the jet the same as that of the surrounding gas. Solutions are obtained in form of a series, the first term corresponding to the incompressible case. In the two-dimensional case, the compressibility effect for laminar and turbulent flow is, respectively, to decrease and increase the width of the mixing region. For axially symmetric jets, the same holds also for laminar flow, whereas for turbulent flow the tendency is reversed.

H. Schuh, Sweden

1283. Kondo, J., and Kobayashi, R., Anisotropy in a turbulent wake behind a circular cylinder, Proc. Sixth Japan nat. Congr. appl. Mech., Univ of Kyoto, Japan, 303-310, 1956.

Hot-wire turbulent velocity records taken behind a cylinder are sampled and recorded on punched cards. Standard deviation and auto-correlation measurements using digital techniques were attempted. L. S. G. Kovasznay, USA

1284. Sasajima, H., and Takagi, M., The effect of breadth on the frictional resistance of a flat plate (in Japanese), *J. Soc. nav. Arch. Japan* **101,** 131-138, Aug. 1957.

The effect of finite breadth on the turbulent frictional resistance of a flat smooth plate is examined theoretically. Athwart flow is neglected as the first approximation. The elliptic coordinates are successfully introduced to the equations of motion. The velocity distribution is obtained by the momentum transfer theory.

Calculated frictional resistance is given as a function of aspect ratio as well as Reynolds number, and a comparatively good coincidence has been obtained with the existing experimental data.
T. Inui, Japan

1285. Lunev, V. V., Laminar boundary layer of a compressible gas over a flat plate with large wall-to-stream temperature changes (in Russian), *Prikl. Mat. Mekh.* **20,** 3, 395-401, May-June 1956.

Crocco's transformation is used to obtain the usual equations for the nondimensionalized shear stress $\tau(x, u)$ and enthalpy $i(u)$ when the boundary values are independent of x. Assuming existence and uniqueness of the solution for which the shear stress is separable, $\tau = X(x)\,g(u)$, attention is focused on approximate solutions of the resulting pair of nonlinear differential equations for $g(u)$ and $i(u)$ when the nondimensionalized product of density and viscosity $f = \rho\mu/\rho_\infty\mu_\infty$ and the Prandtl number σ vary in a known manner with temperature, and hence u. An iteration method is proposed: assume a shear profile, $G(u) = g(u)/g(0)$, solve for i by quadratures using σ = constant; using this first approximation for i, evaluate the corresponding f and solve for the next approximation in shear profile G, etc. The method is shown to converge in domains represented in author's figs. 3 and 4 (air) by considering linearized perturbation equations about the exact solutions. In case of variable σ, the transformation $\sigma\,dt = di$ is inserted in the scheme.

Apparently the success of the method rests not only on the relative smallness of $1-\sigma$ and on the known weakness of dependence of G on f, but also on the fact that identical G's obtain for different but constant f's. In other words, G depends on *variations* in f rather than on the absolute value of f.
M. Morkovin, USA

Aerodynamics of Flight; Wind Forces

(See also Revs. 1103, 1241, 1249, 1251, 1266, 1334, 1344, 1405, 1423, 1427)

1286. Neumark, S., and Thwaites, B., Velocities on two-dimensional closed and semi-infinite aerofoils at zero incidence, *Aero. Res. Counc. Lond. Rep. Mem.* 2994, 14 pp., 1957.

An attempt is made to clarify the position as to the comparative two-dimensional velocity distributions on a thin doubly symmetrical airfoil and on the corresponding semi-infinite body, the front part being the same in the two cases. It is shown that the approximate linear method may be used with advantage to investigate the problem. The method provides a simple general proof that the supervelocity at the mid-chord station of a closed doubly symmetrical profile of any shape is approximately halved when the rear half is replaced by a semi-infinite parallel body. No such simple relationship applies to the entire chordwise distribution on the front part. An exact solution of the velocity distribution has been obtained for one particular semi-infinite profile and several alternative examples have been studied by the linear method. It is found that the ratio of maximum supervelocities may often considerably exceed 0.5, and sometimes rise to nearly 1.0.
From authors' summary

1287. Bishop, R. A., and Cane, E. G., Charts of the theoretical wave drag of wings at zero-lift, *Aero. Res. Counc. Lond. curr. Pap.* 313, 15 pp. + 17 figs., 1957.

Charts are presented for the theoretical wave drag at zero lift of straight-tapered wings with streamwise tips, and with double-wedge or parabolic-arc sections. A bibliography of theoretical reports is included, and their contents are reviewed.
From authors' summary

1288. Graham, M. E., Curves of lift-to-drag ratios of certain midwing monoplane configurations in supersonic flight, *Douglas Aircr. Co. Rep.* SM-22640, 15 pp., Nov. 1956.

Curves are presented of lift-drag ratios of certain midwing monoplane configurations in supersonic flight. The configuration is essentially a uniformly loaded thin wing (of elliptic planform) and circular arc profiles of same radius centrally mounted on a "supersonically area-ruled" Sears-Haack fuselage. The theoretical background was presented and discussed in previous reports. From author's summary

1289. Lock, R. C., A note on the application of the supersonic area rule to the determination of the wave drag of rectangular wings, *J. Fluid Mech.* **2,** 6, 575-582, Aug. 1957.

Author alludes to undocumented suggestions that the supersonic area rule gives incorrect results for the wave drag at zero lift of wings with straight supersonic edges, and then proceeds to show that this is not the case for wings of rectangular planform. It is remarked that the demonstration could be extended easily to cover the case of untapered swept wings, but no further discussion is presented of cases for which the supersonic area rule does or does not yield correct results. Reviewer recommends that readers interested in this subject should also consult the paper of Lomax and Heaslet, *J. aero. Sci.* 1061-1074, Dec. 1956.
J. R. Spreiter, USA

1290. Ting, L., Generalization of integral relationships with applications in wing-body interference, wing theory, and diffraction of pulses, *Polyt. Inst. Brooklyn, Aero. Lab. Rep.* 379, 36 pp. + 8 figs., Apr. 1957.

Theorem based on linearized potential flow theory is derived relating integrated lift to integrated normal velocities on a supersonic edged surface cut from an arbitrarily shaped cylinder generated about free-stream axis. This interesting theorem generalizes previous theorems for planar or multiplanar systems and shows lift on one side of any supersonic edged surface with an unswept trailing edge lying in a Mach plane to be twice average angle made by surface with respect to free stream divided by $(M^2-1)^{1/2}$. Similar theorem is derived for integrated pressures in a notch diffracting a weak two-dimensional shock.
H. Lomax, USA

1291. Sacks, A. H. Vortex interference effects on the aerodynamics of slender airplanes and missiles, *J. aero. Sci.* **24,** 6, 393-402, 412, June 1957.

Vortices shed by wings and body noses of airplanes and missiles can have important nonlinear effects on the stability and control forces developed by downstream empennages. Such effects occur at angles of attack and sideslip depending on configuration. In previous papers author has presented general results based on slender-body theory for all forces and moments except drag acting on slender wing-body-tail combinations. In present paper he

applies general results to simple models (no body) to illustrate the main nonlinear effects of vortices on stability and control; i. e., pitchup, directional instability, etc. Examples include planar and cruciform configurations, and paper contains many excellent vortex pictures from the water tank. No rolling-moment results are presented. Author ignores motion of vortices due to presence of empennage in his examples, although water-tank experiments show large motions. Further investigation of this question is desirable.

Reviewer believes that usefulness of general results would be enhanced if used in conjunction with a method for accurately calculating vortex paths in presence of wing-body-tail configuration. Step-by-step calculation methods are possible which are well suited to automatic computation.

J. N. Nielsen, USA

1292. Kordes, E. E., Kruszewski, E. T., and Weidman, D. J., Experimental influence coefficients and vibration modes of a built-up 45° delta-wing specimen, *NACA TN* 3999, 41 pp., May 1957.

Experimental influence coefficients and vibration modes and frequencies of a built-up 45° delta-wing specimen are presented. The symmetrical and antisymmetrical static influence coefficients were obtained on a three-point support. The first 10 vibration modes and frequencies were obtained for an essentially free-free condition. A detailed description of the structural properties of the specimen is also given. From authors' summary

1293. Schultz, G., Efficiency of flaps in supersonic flow (in German), *Z. Flugwiss.* **5**, 1, 15–22, Jan. 1957.

Linearized supersonic theory is used to determine forces and moments due to trailing edge flaps. Aerodynamic coefficients are given for the total lift, flap load, induced drag, pitching moment, hinge moment, rolling moment, and induced yawing moment. Three spanwise flap locations are considered. A delta wing with interior flap is used as an example. H. P. Liepman, USA

1294. Pinsker, W. J. G., Control surfaces restrained by viscous friction as a means of damping aircraft oscillations, *Aero. Res. Counc. Lond. Rep. Mem.* 2962, 26 pp., 1957.

A method is described of controlling the phase of the free motion of control surfaces by viscous friction and geared masses. Substantial improvements in the damping of aircraft oscillations can be achieved if such devices are applied to existing or additional control surfaces or to tabs attached to such controls. The merits of various arrangements are discussed and formulas for the determination of optimum conditions are derived.

The conclusions are illustrated by numerical examples.

From author's summary

1295. Croom, D. R., and Huffman, J. K., Investigation at transonic speeds of deflectors and spoilers as gust alleviators on a 35° swept wing, *NACA TN* 4006, 19 pp., June 1957.

An investigation was made in the Langley high-speed 7- by 10-ft. tunnel by means of the transonic-bump method to determine the gust-alleviation capabilities of spoilers and deflectors when mounted on a 35° swept semispan wing having NACA 65A006 airfoil sections. The Mach number range was from 0.40 to 1.15, and the angle-of-attack range was from −8° to or beyond the stall.

The gust-alleviation capabilities (as indicated by the reduction in lift-curve slope) were almost constant (approximately a 20% reduction in lift-curve slope) throughout the Mach number range from 0.40 to 1.15 for both the deflector and the spoiler-deflector combination. Increased drag resulted from the deflection of these controls and indicated that they would also be effective as aerodynamic brakes during slowdown to rough-air speed.

At low subsonic speeds, the wing with the deflector or the spoiler-deflector control caused no marked effect on the stability of the model; however, at high subsonic speeds (Mach number above about 0.8), the controls caused a decrease in stability and a pitch-up was noted at an angle of attack of about 6° where the lift curve became nonlinear. At supersonic speeds, the wings with the controls were less stable than the plain wing; and both wings exhibited pitch-up, as did the plain wing, at an angle of attack of 12° where the lift curve became nonlinear.

From authors' summary

1296. Croom, D. R., and Huffman, J. K., Investigation at low speeds of deflectors and spoilers as gust alleviators on a model of the Bell X-5 airplane with 35° swept-wings and on a high-aspect-ratio 35° swept-wing—fuselage model, *NACA TN* 4057, 37 pp., June 1957.

An investigation was made at low speeds in the Langley 300-mph 7- by 10-ft tunnel to determine the gust-alleviation capabilities (reduction in lift-curve slope) of spoilers and deflectors on a high-aspect- ratio 35° swept-wing—fuselage model and a 1/4-scale model of the Bell X-5 airplane with 35° swept wings.

The results indicate that deflector and spoiler-deflector types of controls can be designed to provide considerable gust alleviation for a swept-wing airplane while still maintaining stability and control. From authors' summary

1297. Phillips, W. H., Brown, B. P., and Matthews, J. T., Jr., Review and investigation of unsatisfactory control characteristics involving instability of pilot airplane combination and methods for predicting these difficulties from ground tests, *NACA TN* 4064, 27 pp. + 20 figs., Aug. 1957.

A number of examples are presented of control difficulties which appear to result from a tendency for dynamic instability of the combination of pilot, control system, and airplane. The unsatisfactory characteristics involved have been encountered most frequently with hydraulic-power control systems, although several cases have also been experienced with conventional control systems. Tests of a bomber and a fighter airplane with experimental power control systems have been made to study this problem further.

The results of the investigation show that control difficulties of the type considered have always been associated with a marked phase difference between the pilot's control force and the associated control-surface deflection. The presence of static friction in the control valves of hydraulic-power control systems was found to be the explanation for unsatisfactory characteristics in several airplanes equipped with such systems. Definite limits or simple rules for the tolerable amount of valve friction appear to be difficult to establish because of the large number of variables which may influence the problem.

A method of analysis of the stability of an airplane under control of the pilot is presented which provides a physical explanation of the problem and appears to predict qualitatively the difficulties encountered in flight. A method of making ground tests of a control system, with the use of a simple simulator to represent the airplane response characteristics, was also investigated. This method is suggested for detecting undesirable control characteristics of the type under consideration before actual flight tests of a new airplane are attempted.

From authors' summary

1298. Brown, B. P., and Reeder, J. P., Some effects of valve friction and stick friction on control quality in a helicopter with hydraulic-power control systems, *NACA TN* 4004, 8 pp., May 1957.

Tests have been made of a hydraulic-power-controlled helicopter to determine the effect of friction in the servovalves and the effect of stick friction when the valve friction is present.

The tests showed that, when the valve friction is equivalent to about 1 3/4 pounds of force at the stick, precision flying is

difficult and more work is required of the pilot. Control quality is improved by adding an amount of stick friction that is equal to the valve friction. The total of the two frictions, however, should not exceed 3 pounds. The lowest valve-friction value tested was 1/4 pound, and the pilots considered the effect to be negligible and therefore considered any stick friction to be unnecessary. The pilots believed that the system was markedly improved when the valve friction was reduced from 1 3/4 pounds to 1/4 pound. The addition of feel devices resulted in an over-all improvement in the control systems and was therefore considered to be very desirable. From authors' summary

1299. Thorpe, A. W., An approximation to the slow mode of longitudinally disturbed motion of an aircraft in level flight, *Aero. Res. Counc. Lond. Rep. Mem.* 2907, 27 pp., 1957.

Here is an easy-to-apply, relatively accurate method for determining the motion of the phugoid mode. Coefficients of the oscillatory and non-oscillatory function of motion are tabulated as functions of aerodynamic and inertia coefficients. The motions include change of longitudinal velocity, angle of attack, pitching velocity, and angle of pitch; in terms of an initial disturbance in any of these four motions or in terms of the pitching moment due to elevators.

In the derivation, the equations of motion are simplified by neglecting the inertia in pitch and the rate of change in incidence. The effective initial conditions needed to impose on the approximate equations are uniquely determined by the quick-period motion which is assumed to take place infinitely quickly. The equations are of second order, resulting in general algebraic solutions.

Comparisons of numerical examples with fourth-order solutions are quite good. J. De Young, USA

1300. Few, A. G., Jr., and King, T. J., Jr., Some effects of tail height and wing plan form on the static longitudinal stability characteristics of a small-scale model at high subsonic speeds, *NACA TN* 3957, 62 pp., May 1957.

An investigation has been made in the Langley high-speed 7- by 10-ft tunnel to determine some effects of tail height and wing planform on the static longitudinal stability characteristics of a complete, small-scale model at high subsonic speeds. The model had both a low-tail position (wing chord plane extended) and a high-tail position (65% semispan above the wing chord plane extended). The wings were 4% thick, had an aspect ratio of 3, and had various taper ratios and angles of sweep. Three wings had a taper ratio of 0.50 and quarter-chord sweep angles of 25°, 30°, and 35°; whereas the fourth wing had 30° of sweep and a taper ratio of 0.20. The Mach number range extended from about 0.80 to 0.94 with corresponding Reynolds numbers ranging from about 1.17×10^6 to 1.29×10^6 for average test conditions.

From authors' summary

1301. Brousse, P., and Poncin, M. H., Solution of Stokes-Beltrami problems in aeronautical engineering (in French), *Publ. sci. tech. Min. Air, France* no. 370, 323, 67 pp., 1956.

Author studies in a given domain D of the upper half plane $y > 0$ the integrals of a class of singular elliptic partial differential equations

$$\Delta\chi(x,y) + (P_1/y)\,[\partial\chi(x,y)/\partial y] + (P_2/y^2)[\chi(x,y)] + P_3 = 0. \quad [E]$$

having some coefficients which become infinite on the part Δ of the boundary contained in the x-axis. Examples of particular forms of [E] arising in various problems of the mechanics of structures and the mechanics of fluids are given. Author employs the techniques of formal mathematical analysis in pursuing the task of making the influence of the singular line analytically precise. The theory is illustrated by a number of applications in particular domains bounded by straight lines and the arcs of circles.

M. L. Stein, USA

1302. Willmer, M. A. P., On the generalized simple system for automatic stabilisation of a helicopter in hovering flight, *J. Helicop. Assn.* **10,** 2, 77–102, Oct. 1956.

Paper describes a method of stabilizing a helicopter in hovering flight by means of a properly timed cyclic variation of the pitch. Similar methods of achieving this are mentioned and the present paper claims a further improvement along that line. The fundamental idea consists in fitting a control system into the rotating element and transmitting an appropriate cyclic pitch variation to the rotor blades, which results in an improved stability. Author shows that a system of this kind with one degree of freedom is amenable to a differential equation of the second order in terms of the automatic response quantity. He calls such system "the system of the first order" (not to be confused with the order of the differential equation which is of the second order here).

After this he investigates the system of the "second order" (in his terminology) which, in reality, is a differential system of the fourth order. The frequency response method is then applied to obtain numerical data for the various parameter values.

Paper is written in terms of aeronautical engineering practice and some basic mathematical fundamentals are left more or less aside. What is apparent from the paper (although not stated) is that the method ultimately reduces to the classical problem of stability of solutions of differential equations with periodic coefficients. The latter are introduced in the form of "cyclic pitch variation" effected by rotating control element and possible under the conditions of a hovering flight.

N. Minorsky, France

1303. Murphy, C. H., Jr., The prediction of nonlinear pitching and yawing motion of symmetric missiles, *J. aero. Sci.* **24,** 7, 473–479, July 1957.

Approximate methods are worked out to determine nonlinear stability of combined pitching and yawning motion. In comparison with exact numerical integration, accurate results and good agreement with experiments could be achieved. Results are presented in amplitude planes showing the character of motion to initial conditions. F. Schultz-Grunow, Germany

1304. Phillips, W. H., Load implications of gust-alleviation systems, *NACA TN* 4056, 11 pp., June 1957.

A review is presented of the factors affecting gust loads and the methods or devices which reduce these loads. Aerodynamic devices which reduce the lift-curve slope include spoiler-deflector controls, for which some data are presented in the Mach number range from 0.4 to 1.1. Systems are also considered in which a sensing device is used to operate gust-alleviation controls. Two basically different types of sensing devices are possible, the load-sensing type and the angle-of-attack-sensing type. These devices are compared and their limitations discussed. Some preliminary flight measurements of wing-root bending moment due to turbulence are presented for a gust-alleviation system installed in a small twin-engine transport airplane. This system increased the wing-root bending moments as compared with those of the basic airplane. This increase resulted from the fact that the system as tested was adjusted to reduce acceleration and, as a result, overcompensated for the wing-root bending moments due to gusts. Some flight measurements of the effects of a yaw damper on the tail loads of a bomber airplane are also presented.

From author's summary

1305. Bismut, M., Regimes of uncontrolled roll (in French), *Recb. aëro.* no. 58, 4–8, May-June 1957.

In high-speed free-drop tests of aircraft models, uncontrolled roll about an axis close to the longitudinal one has been observed.

Explanation of this phenomenon has been found by retaining in the equation of motion nonlinear inertia terms. These rigorous equations of motion were then simplified to a form more suitable for practical analysis by assuming that the roll vector forms a small angle with aircraft longitudinal axis. In addition, results of studies on an analog are presented. Finally, it is indicated that uncontrolled roll can be encountered in full-scale aircraft flying at high altitudes. W. Z. Stepniewski, USA

1306. Burns, Anne, Fatigue loadings in flight: loads in the wing of a Varsity, *Aero. Res. Counc. Lond. curr. Pap.* 285, 16 pp. + 8 figs., 1956.

Data are presented on the number of load cycles of various magnitudes occurring in the wing of a Varsity in normal ground and flight conditions. The conditions include taxiing, take-off, landing, and flight in turbulence. The relative importance of the loads in the different conditions is illustrated by reference to the loads in a typical flight.

A relationship is determined between wing loads and accelerations in turbulence so that the test results can, if required, be related to gust data obtained operationally by means of the counting accelerometer. From author's summary

1307. Wells, E. W., Fatigue loadings in flight loads in the fuselage and nose undercarriage of a Varsity, *Aero. Res. Counc. Lond. curr. Pap.* 287, 8 pp. + 5 tables + 6 figs., 1956.

Flight tests have been made on a Varsity to obtain data on the fatigue loads in the fuselage and the nose undercarriage. The data are tabulated in terms of the number of load ranges of a given magnitude occurring during various ground and flight conditions. An estimate is made of the loads in a typical operational training flight to show the relative importance of the various conditions. A relationship is established between the fuselage loads and the accelerations at the aircraft c.g. when flying in turbulence; this enables the results from the flight tests to be linked to operational data obtained on gusts.

From author's summary

Aeroelasticity (Flutter, Divergence, etc.)

(See Rev. 1294)

Propellers, Fans, Turbines, Pumps, etc.

(See also Revs. 1233, 1253, 1298, 1329, 1355, 1394, 1396, 1434)

Book—1308. Stepanoff, A. J., Centrifugal and axial flow pumps; theory, design and application, 2nd edition, New York, John Wiley & Sons, Inc., 1957, vii + 462 pp. $12.

This new enlarged second edition devotes 460 pages to design problems of radial flow and axial flow pumps.

The first five chapters present the basic fluid flow phenomena and the definitions and classifications (according to specific speed) necessary for the design of pumps. The geometrical layout of radial discharge impellers and the corresponding diffusers and volutes are discussed in chaps. 6 and 7. Chapter 8 gives methods for designing axial flow pumps.

The origin of various losses and their estimation are exposed in chaps. 9 and 10. Various means of balancing the axial thrust are discussed in chap. 11, and chap. 12 is devoted to the cavitation phenomena. Chapters 13 to 17 treat special problems of pumps, such as means of extending their range, calculation of critical speed, and many mechanical problems. These chapters include the drawings of many proven designs.

The 18th chapter shows the design and performance of jet pump systems and the book concludes with a chapter about water-hammer problems.

Reviewer finds that the book is written by somebody with many years of experience in pump design and usage. Editing of the book is beyond reproach. Accordingly, there are many observations, thoughts, and drawings in this book well worth being in a pump designer's possession.

However, the number of questionable statements ranging all the way from unclear to wrong is amazing. In fact, the book is permeated by opinions and "observations" which are in contradiction with the basic principles of fluid flow. These statements are not just accidental slip-ups; they are repeated whenever the occasion presents itself. Apparently the author intends to disregard the findings of fluid flow incorporated in every text book, and to create a new "philosophy of fluid flow." The publishing of this book by an otherwise reputable publishing house is so amazing that three examples illustrating the above generalization are cited: (1) "Prerotation in the suction pipe is caused by the tendency of the liquid to follow a path of least resistance on its way to enter impeller channels. This becomes evident when the prerotation is in a direction opposite to that of the impeller." (2) "A pound of water in an enclosed vessel under 100 psi static pressure possesses energy of compression only which is negligible; but a pound of water at the bottom of a standpipe 231 feet high possesses 231 ft lb of pressure energy." (3) "Note that, having no part in maintaining or transmitting pressure energy, solids in suspension cannot convert their kinetic energy into pressure."

These statements are three of many wrong ones and are not isolated, i.e., the wrong ideas are used to construct design procedures. For instance, author shows, based on Statement 1 above, how inlet velocity triangles are constructed as follows: "For a given impeller speed, there is only one capacity at which the liquid will approach the impeller meridianally or without prerotation; see Figure 3.7A."

In addition to such statements based on misunderstanding of the basic fluid phenomena there are many which are questionable since they might be true under special circumstances.

"In an axial flow pump, liquid particles leave the impeller at the same radius at which they enter."

"All theoretical discussions and practical design of axial flow pumps are based on the assumption of constant axial velocity."

"To maintain the same axial velocity along the radii the pitch for all radii should remain constant to assure the same degree of impelling action for several streamlines of different radii." (Pitch is defined as πD tau β_2, where β_2 is the relative exit angle at diameter D.)

This is the book with the largest number of original statements the reviewer has seen so far. Unfortunately, most of them are wrong. The uninitiated might therefore have a hard time to separate the wrong statements from the correct ones, which impairs the usefulness of the well-edited book, containing much interesting information. H. P. Eichenberger, USA

1309. Armstrong, W. D., An experimental investigation of the secondary flow occurring in a compressor cascade, *Aero. Quart.* **8,** 3, 240–256, Aug. 1957.

When a nonuniform stream flows through a cascade of compressor blades a three-dimensional secondary motion is generated in the outlet stream. This motion, which consists of a spanwise reorientation of the Bernoulli planes, together with the effects of vorticity components in the stream direction, may be predicted theoretically. In this paper experimental results obtained on a 6-in. chord cascade are reported. The experimental and computed

outlet angles are compared and the discrepancies are explained qualitatively. Additional particle track and visualization experiments were designed to investigate the local blade flows and the effects of the nose vortices.

From author's summary by T. P. Torda, USA

1310. Levine, P., Two-dimensional inflow conditions for a supersonic compressor with curved blades, *J. appl. Mech.* **24,** 2, 165–169, June 1957.

Method is developed for calculation of flow distribution in entrance region of two-dimensional diffusing cascades of sharp-edged blades for steady, isentropic, supersonic flow having subsonic component normal to cascade axis. Shock wave losses are neglected, as are reflected expansion waves at intersections of expansion waves and shock waves. For blades of circular-arc convex surface, general numerical results are obtained for a range of blade geometry and upstream Mach number.

W. G. Cornell, USA

1311. Benser, W. A., and Finger, H. B., Compressor stall problems in gas-turbine-type aircraft engines, *SAE Trans.* **65,** 187–200, 1957.

1312. Carmichael, A. D., and Horlock, J. H., Actuator disc theories applied to the design of axial compressors, *Aero. Res. Counc. Lond. curr. Pap.* 315, 14 pp. + 4 figs., 1957.

Author states "A relatively simple method is given for finding the flow conditions in the proximity of blade rows when the variation in whirl or tangential velocity is known. The radial variations in axial velocity that would be attained in radial equilibrium are first estimated using the radial equilibrium equations and then modified to allow for the interference effect of the adjacent blade rows on the axial velocity distribution between the blade rows."

"The second part of the paper gives some solutions to the radial equilibrium equations for a useful general variation in whirl velocity. This variation gives constant radial work rotors and includes the free vortex and constant reaction designs as particular solutions."

"The combination of these results gives a design method which should be useful in the design of axial compressors."

However, the notation used in the special solutions, appendix, and figures are not explained, and it would require a considerable analysis to ascertain how to use the ideas presented in the report.

A. S. Andes, USA

1313. Tryhorn, D. W., Millington, B. W., Bradbury, C. H., Judson, C. A., and Kellett, E., Symposium on superchargers and supercharging, Instn. mech. Engrs. Auto. Div., Prepr., 45 pp., Nov. 1956.

1314. Dunavant, J. C., Cascade investigation of a related series of 6-percent-thick guide-vane profiles and design charts, *NACA TN* 3959, 48 pp., May 1957.

A new guide-vane blade series for high critical speeds of improved section characteristics has been derived. Low-speed cascade tests were made of four blade sections of this series at solidities of 0.75, 1.00 and 1.50. From these tests, design angles of attack were selected and are presented as a method of determining camber for guide-vane turning angles as high as 50°. The results of a number of simple computations made to estimate the high-speed characteristics of the blade series are presented.

From author's summary

1315. Fenemore, A. S., Linear induction pumps for liquid metals, *Engineer, Lond.* **203,** 5286, 752–755, May 1957.

1316. Shevell, R. S., The versatile jet transport, *SAE Trans.* **65,** 208–218, 1957.

1317. Hooker, R. J., Orion—a gas-generator turbocompound engine, *SAE Trans.* **65,** 293–330, 1957.

1318. Davison, E. H., Compressor and turbine matching considerations in turboprop engines, *SAE Trans.* **65,** 100–111, 1957.

1319. Shchapov, N. M., Bernoulli equation for slightly compressible liquids (in Russian), *Izv. Akad. Nauk SSSR Otd. tekh. Nauk* no. 2, 117–119, 1957.

Author introduces a correction factor into the pressure head in the energy equation, which depends on E, elasticity of liquid: $(1 - p/2E)$, and is always less than unity. Disregarding that correction in pressure penstocks can lead to undervaluation of the turbine efficiency by as much as 0.5%.

S. Kolupaila, USA

1320. Kruglov, M. G., The gas exchange process in a two-stroke internal-combustion engine with variable inlet and outlet pressures (in Russian), Internal Combustion Engines, Moscow, Mashgiz, 1955, 46–54; *Ref. Zh. Mekh.* no. 11, 1956, Rev. 7393.

An experimental investigation of the gas exchange processes in a four-cylinder, two-stroke internal-combustion engine of the compression-ignition type, TaAZ, with all cylinders running and with only the two end cylinders firing.

The great influence of the exhaust system and the work of the adjacent cylinders, on the running of the engine, is noteworthy; in all running conditions investigated, the greatest content of carbon dioxide in the combustion gases was obtained with an air-excess coefficient of 1.1. For a particular value of the cyclic fuel feed, empirical relationships are derived for the cylinder resources at opening of the exhaust and scavenging valves, the scavenge air pressures, and the engine revolutions.

M. A. Peshkin

Courtesy Referativnyi Zhurnal, USSR

Translation, courtesy Ministry of Supply, England

1321. Vyrubov, D. N., Problems of fuel combustion in compression-ignition engines (in Russian), Internal Combustion Engines, Moscow, Mashgiz, 1955, 80–86; *Ref. Zh. Mekh.* no. 11, 1956, Rev. 7394.

Some results are discussed of tests made by the "Internal Combustion Engines" division of the Moscow Higher Technical College on mixture formation in compression-ignition engines.

M. A. Peshkin

Courtesy Referativnyi Zhurnal, USSR

Translation, courtesy Ministry of Supply, England

1322. Orlin, A. S., The calculation of the gas exchange in two-stroke internal combustion engines and the development of their structural arrangement (in Russian), Internal Combustion Engines, Moscow, Mashgiz, 1955, 13–30; *Ref. Zh. Mekh.* no. 11, 1956, Rev. 7395.

Author describes the principal results of tests made by the "Internal Combustion Engines" division of the Moscow Higher Technical College on the process of gas exchange in internal-combustion engines.

M. A. Peshkin

Courtesy Referativnyi Zhurnal, USSR

Translation, courtesy Ministry of Supply, England

1323. Venning, B. H., Analogue computer development with reference to helicopter applications, *J. Helicop. Assn.* **11,** 2, 77–96, Apr. 1957.

Flow and Flight Test Techniques

(See also Revs. 1238, 1261, 1279, 1280, 1283, 1307, 1309)

1324. Tachmindji, A. J., and Dickerson, M. C., The measurement of oscillating pressures in the vicinity of propellers, *David W. Taylor Mod. Basin Rep.* 1130, 33 pp., Apr. 1957.

Measurements were conducted with four propellers having, respectively, 4, 3, 2, and 1 blade, and in the 12-in. variable-pressure water tunnel at DTMB. Test results obtained in open water agreed well with those obtained in tunnel, provided thrust and torque were the same.

Propellers were operated in uniform velocity field. Oscillating pressures were measured by means of a Hathaway pressure gage having a maximum range of ± 0.5 psi and located in free stream, both ahead and behind the propeller and on an imaginary plane parallel to propeller axis. Further details of instrumentation used are given in *DTMB Rep.* 1107, 1957.

Effect of rpm, propeller loading, and speed coefficient are investigated. As first results show no dependence on speed for sufficiently high Reynolds number, all further measurements were conducted in 12-in. tunnel at constant value of 900 rpm.

Maximum pressure amplitude occurs at a distance of about 15% of diameter ahead of plane of rotation. Effect of number of blades indicates that percentage of blade frequency component to total oscillating pressure for all frequencies increases with increasing number of blades; however, amplitude of both decreases.

It is shown also that it is possible to predict approximately the magnitude of free-space oscillating pressure for a propeller having a large number of blades when results of a similar propeller with fewer blades are known. Agreement between experimental and computed values is reasonably good.

E. Steneroth, Sweden

1325. Francis, J. R. D., The speed of drifting bodies in a stream, *J. Fluid Mech.* **1,** 5, 517–520, Nov. 1956.

Carefully conducted experiments in the Civil Engineering Laboratories of Imperial College show no measurable difference between the speed of floating bodies and the mean speed of the layer of water in which the bodies are located. Since floating vertical cylinders are used to determine river speeds, results of paper are of practical significance.

V. G. Szebehely, USA

1326. Takeda, S., and Suzuki, H., A new pressure-magnifying type sensitive pressure gauge, Proc. Sixth Japan nat. Congr. appl. Mech., Univ. of Kyoto, Japan, Oct. 1956, 415–418.

A new pressure gage has been developed in which small pressure differences acting on corrugated diaphram capsules are magnified to large pressure differences on two additional stronger metallic bellows. A dial indicator is then attached to the stronger bellows through a mechanical linkage. A gage constructed on this principle had a maximum range of 5 mm of water, and tests indicate an accuracy of 1% of the full-scale range. The time constant of the transient response is about 0.2 seconds. Authors suggest that this gage could replace instruments such as tilting manometers, ring balance manometers, or bell-type manometers, which are not easily handled or which have too large a lag of indication.

G. J. Nothwang, USA

1327. Eichhorn, R., and Irvine, T. F., Jr., Description of a new sensitive micromanometer, ASME Semiann. Meet., San Francisco, Calif., June 1957. Pap. 57-SA-63, 7 pp.

1328. Kemp, J. F., The Leon tube: an instrument for measuring flow speeds in water, *J. sci. Instrum.* **34,** 10, 390–392, Oct. 1957.

A description is given of the construction and performance characteristics of an instrument which is capable of measuring flow speeds in water "at a point" over a range of 1 to 14 fps. The accuracy at 1 fps is approximately 1½% and improves rapidly with increasing speed. The Leon tube is of robust and compact construction and is, in effect, a combination of a differential pressure tube and a differential liquid manometer. The pressure factor of the tube, which is a function of Reynolds number, is most readily determined in a wind tunnel. The instrument has proved to be particularly suitable for the performance of velocity traverses in open channels.

From author's summary

1329. Forshaw, J. R., and Taylor, H., The measurement of high frequency alternating pressures in gas turbines, *Aero. Res. Counc. Lond. Rep. Mem.* 2990, 14 pp., 1957.

The measurement of alternating pressures in gas turbines could not be achieved by existing techniques. The pressures consisted of small-amplitude alternating pressures superimposed on pressures up to 100 psi and at temperatures up to 250 C in compressors and up to 850C in turbines. The frequencies of the predominant harmonic components varied from 100 to 17,000 cps and those for the smaller components up to 40,000 cps.

Improvements were required in the recording techniques which are reported elsewhere but the changes in amplifiers are described. The development of a capacity pressure element to record the alternating pressures at a point in a casing is described. A small-diameter diaphragm was used to facilitate installation and to obtain the pressure over as small an area as possible. The diaphragm was arranged near the gas stream and the effect of temperature changes was eliminated by applying a filtered balance air supply behind the diaphragm to permit calibration during the investigation. The balance air supply permits equilization of pressure across the diaphragm so that higher sensitivities can be used.

The alternating pressures decrease sharply with distance from the source, and if the alternating pressure is required at a point other than in the casing, a special approach will be required.

From authors' summary

1330. Dudgeon, E. H., and Michie, W. C., Development of a sensitive rotational viscometer, *Nat. Res. Counc. Canad. mech. Engng. Rep.* MT-34, 13 pp. + 10 figs., Jan. 1957.

A sensitive co-axial rotational viscometer has been designed incorporating certain features to make it especially suitable for use with low viscosity non-Newtonian suspensions. The outer cylinder can be rotated over a considerable range of speeds and the inner cylinder is mounted ... hydrostatic air bearings for increased sensitivity. A lower guard plate is incorporated to eliminate end effect with Newtonian fluids. Different combinations of outer and inner cylinders may be mounted to permit accurate measurement at shear rates up to 3000 sec^{-1}. Viscosities as low as 1 centipoise can be measured conveniently.

From authors' summary

1331. Bruche, E., Application of electron microscopes in aeronautical research (in German), *Z. Flugwiss.* **5,** 2, 43–49, Feb. 1957.

Some examples of the application of the electronic microscope in aeronautics are considered, and attention is drawn to the lack of appreciation of this instrument in German engineering in contrast to that of the United States of America, the USSR, and Japan. It is recommended that more attention should be paid to the "fundamental technical process," which should be traced and considered in problems so far investigated for the most part by integral methods, such as running in of engine components, wear and tear, corrosion, etc.

From author's summary

1332. Holcombe, A. R., 'Dead stick' landing testing techniques, *AGARD Publications, Rep.* 28, 12 pp. + iv. Feb. 1956.

Information gained during United States Navy experiments with dead-stick landings on ten different jet aircraft is presented. Testing methods, glide range determination, and landing techniques are discussed. From author's summary

1333. Murphy, C. H., The measurement of non-linear forces and moments by means of free flight tests, *Aberdeen Prov. Gr., BRL Rep.* 974, 95 pp., Feb. 1956.

The moving of missiles is influenced by nonlinear forces and moments. This fact and the flying at large angles of yaw require the solution of very complex equations.

In this paper author gives a very good solution by a system of linear forces and small angles of yaw. In these linear equations the parameters should be "average values" of the coefficients of the parent nonlinear equation. In this study the relations for parameters of a linear equation which is equivalent to the actual nonlinear equation have been derived. These relations have been proved by actual firing at Aberdeen Proving Ground, where free-flight spark range technique has been applied and a excellent internal consistency has been observed. Good agreement has also been obtained in the wind tunnel.

J. Marinkovic, Yugoslavia

1334. Nickel, K., Moment measurement on free-flight models (in German), *Z. Flugwiss.* **5,** 1, 22–26, Jan. 1957.

Wooden airplane models were launched horizontally by catapult with various speeds under alteration of the position of center of gravity. It is shown that the pitching moments acting on a model in free flight can thus be obtained from observation of flight path alone. Method used is distinguished by its simplicity and independence of any measuring instrument. Author thinks it applicable for determining other aerodynamic forces and moments.

E. Eujen, Germany

1335. Schmidt, R., A new universal flight test equipment (in German), *Z. Flugwiss.* **5,** 6, 161–168, June 1957.

In this paper a new test equipment for flight tests is described which permits a simultaneous and continuous recording of a great number of different phenomena. The described device uses a particular method of recording which differs fundamentally from that of other known systems; it consists in transformation of the investigated phenomena first into electric pulses and then into light pulses of variable duration which are recorded on photographic film in the form of periodically interrupted lines. This procedure offers several advantages with regard to accuracy, simplicity, and reliability. Furthermore, the recording can be made either in the airplane itself, or by means of radiotransmission, with the commonly used radio-communication equipment. Hereby malfunction due to electronic troubles, often encountered in telemetering, can be to a great extent avoided.

From author's summary

1336. Owen, P. R., and Zienkiewicz, H. K., The production of uniform shear flow in a wind tunnel, *J. Fluid Mech.* **2,** 6, 521–531, Aug. 1957.

Paper attempts the production of a nearly uniform shear flow in the working section of a wind tunnel by inserting a grid of parallel rods with varying spacing. The suitable arrangement of the rods is calculated for weakly sheared flows, and the experiments show that the theory is also applicable to strong shear flows. Reviewer thinks that this method of calculating the arrangement of the rods is conveniently useful for the wind-tunnel studies on shear flows.

T. Okamoto, Japan

1337. Morioka, S., Transonic flow with a detached bow wave past a wedge between two parallel plane walls, *J. aero. Sci.* **24,** 11, 831–837, Nov. 1957.

Flow described in title has been calculated by relaxation (subsonic) and characteristic (supersonic) methods. Three tunnel widths were computed for a main stream Mach number of 1.164.

When tunnel width is decreased, bow wave moves forward and surface pressures rise. There appears to be a limiting tunnel width below which steady flow may not exist. Unfortunately the physical dimensions of the configurations computed are not given.

From author's summary by S. H. Maslen, USA

1338. Scott-Wilson, J. B., and Llewelyn-Davies, D. I. T. P., The development of an improved diffuser for a 3 ft. × 3 ft. wind tunnel, *Aero. Res. Counc. Lond. curr. Pap.* 308, 5 pp. + 7 figs., 1956.

1339. Newby, K. W., R.A.E. high-speed wind-tunnel tests of the trailing-edge controls on a delta wing with 52-deg sweepback, *Aero. Res. Counc. Lond. Rep. Mem.* 2999, 22 pp., 1957.

1340. Holder, D. W., North, R. J., and Wood, G. P., Optical methods for examining the flow in high-speed wind tunnels: Part I, Schlieren methods; Part II, Interferometer methods, *AGARD Publications* no. 23, 148 pp., Nov. 1956.

Paper reviews schlieren, direct-shadow, and interferometer methods, particularly those in general routine wind-tunnel use. Experimental details are discussed, including light sources and photographic materials. Bibliography is extensive.

R. C. Pankhurst, England

1341. Lamb, L., and Lin, S. C., Electrical conductivity of thermally ionized air produced in a shock tube, *J. appl. Phys.* **28,** 7, 754–759, July 1957.

The electrical conductivity of shock-heated air at equilibrium temperature from 3500 K to 6200 K, and at densities of the order of 0.01 NTP, has been measured, using the shock wave-magnetic field interaction technique reported by Lin, Resler, and Kantrowitz. The experimental results indicated that the ionization process builds up quickly behind the shock front, and that the measured conductivity agrees quite well with calculated values based on the equilibrium degree of ionization, the electron diffusion cross sections for the molecular species available in the literature, and on a theoretical estimate of the scattering cross sections for oxygen and nitrogen atoms by Hammerling, Shine, and Kivel based on the Hartree potential with appropriate exchange and polarization terms. From authors' summary

1342. Burton, E. J., and Joyce, J. R., Measurements of the size of droplets from convergent-divergent nozzles used in oil burners for steel furnaces, *J. Inst. Fuel* **30,** 198, 395–398, July 1957.

The size distribution by weight of droplets from an oil burner, designed to give the maximum forward thrust, has been measured for two nozzles at fuel flows from 70 to 300 lb/h with atomizing air-to-fuel ratios ranging from 0.7 to 1.7 lb per lb (5 to 12 lb per gal). The method used was to replace the heavy fuel oil by blended wax having the same viscosity, and to analyze the resulting spray of wax droplets which freeze in flight. The results showed that, except at the lowest flow rate, the median size ranged from 47 to 70 micron, which values are comparable with those from typical steelworks burners. The relevant spray parameters at each flow rate are given in the paper. Neither the nozzle profile nor the distance of the fuel pipe from the nozzle entrance had an appreciable effect on the size distributing Two convergent-divergent nozzles were used, designed for atomization by steam, but in these tests they were used with compressed air.

throat diameter 0.375 in. The test equipment was an improved version to that used previously by Joyce. Photographs of droplets are shown for each nozzle, and for various fuel flows (40, 20, and 10 gal/h) and air flows (240 to 50 lb/h). Particle-size distribution is given in charts, for each nozzle.

K. J. De Juhasz, Germany

1343. Cadle, R. D., and Wiggins, E. J., Direct photomicrography of air-borne particles, *A.M.A. Arch. Indust. Health* **12,** 584–591, Dec. 1955.

Collecting airborne particles and examining them under the microscope has the disadvantages of affecting the particle-size distribution, and changing the original shape and size of the particles by impact or coagulation. Direct photomicrography of the particles without removing them from the air is free from that drawback; an advance method and camera for this purpose is described, designed mainly for the particle range of 2 to 100 microns, with the primary purpose of photographing ice-fog particles. General arrangement of the camera with built-in microscope, details of the optical system and the electronic flash circuit are described and illustrated; samples of photomicrographs of lycopodium powder, salt crystals, and stearic acid aerosol particles, taken with various optical objectives, are given.

K. J. De Juhasz, Germany

1344. Newsom, W. A., Jr., Effect of propeller location and flap deflection on the aerodynamic characteristics of a wing-propeller combination for angles of attack from 0° to 80°, *NACA TN* 3917, 45 pp., Jan. 1957.

An investigation has been made to determine the effect of propeller location and flap deflection on the lift, drag, and pitching-moment characteristics of a wing-propeller combination over an angle-of-attack range from 0° to 80°. The model had four propellers, the slipstream from which covered practically the entire span of the wing. The wing had a 30-percent-chord slotted flap and an 8.5-percent-chord slat. Data were obtained for flap deflections of 0°, 20°, 40°, and 60° with the slat off and on. For one propeller position the power input to the model was measured and tuft studies of the flow on the wing were made. The data are analyzed to assess the feasibility, from consideration of stability and control, of a tilting-wing vertical-take-off-and-landing airplane with the wing pivoted behind the primary wing structure to provide a desirable structural configuration. The main object of the investigation was to determine whether advantage might be taken of the forward shift of the center of gravity of the airplane, as the wing is tilted from an angle of attack of 90° to 0°, to minimize the change in trim pitching moment throughout the transition speed range for such a configuration. The results indicate that, with proper propeller position and programming of flap deflection, it is possible to design a configuration of this type in which essentially no change in trim is required throughout the transition from hovering to normal unstalled forward flight.

From author's summary

1345. Baals, D. D., Model selection and design practices applicable to the development of specific aircraft, *AGARD Publications, Rep.* 21, 28 pp. + vii, Feb. 1956.

Rapid advances in aircraft performance and the critical nature of transonic and supersonic flows have limited the generalization of research results and led to the need for extensive specific model investigations. Factors pertinent to a specific model development program are discussed, together with the major aerodynamic and mechanical requirements of model design. Airframe aerodynamic problems, including the influence of inlets, are considered, but the internal aerodynamics of the engine proper are excluded. Five basic development and five special-purpose models are discussed as the typical array necessary for the development of a present-day supersonic fighter.

From author's summary

1346. Holzhauser, C. A., and Bray, R. S., Wind-tunnel and flight investigations of the use of leading-edge area suction for the purpose of increasing the maximum lift coefficient of a 35° swept-wing airplane, *NACA Rep.* 1276, 24 pp., 1956.

An investigation was undertaken to determine the increase in maximum lift coefficient that could be obtained by applying area suction near the leading edge of a wing. This investigation was performed first with a 35° swept-wing model in the wind tunnel, and then with an operational 35° swept-wing airplane which was modified in accord with the wind-tunnel results.

The wind-tunnel and flight tests indicated that the maximum lift coefficient was increased more than 50% by the use of area suction. Good agreement was obtained in the comparison of the wind-tunnel results with those measured in flight.

From authors' summary

Thermodynamics

(See also Revs. 1247, 1313, 1375, 1382)

Book—1347. Munster, A., Statistical thermodynamics [Statistische Thermodynamik], Berlin, Springer-Verlag, 1956, x + 852 pp. DM 138.

Reviewer considers this book to be in a very real sense a successor to the "Statistical thermodynamics" of Fowler and Guggenheim. It covers the same topics and, in about twice as much space, gives a more leisurely and broader introduction to the foundations as well as the results of research which has progressed steadily since the earlier book was written. The many references to the book by Fowler and Guggenheim also suggest that a knowledge of its contents is desirable before reading the newer book, although this is not necessary.

Since the work is so much of a treatise, it is hardly possible to list all of its 142 sections, but to give an idea of the material covered, the contents can be concisely described as follows. The first part on Foundations is composed of seven chapters entitled: Classical statistics in μ-space (Maxwell-Boltzmann statistics), Quantum-statistics of localized systems (Darwin-Fowler method), Quantum-statistics of non-localized systems (Bose-Einstein and Fermi-Dirac statistics), Classical statistics in Γ-space (Gibbs statistics), General quantum-statistics, Grand partition functions-Fluctuations, and molecular distribution functions. The integral equations of Born-Green, of Mayer and of Kirkwood are introduced in this last chapter. After this thorough treatment of statistics and thermodynamics in the first 300 pages of the book, author applies the theory to gases, solids, and liquids.

The second part on the theory of gases contains chapters on Ideal gases, Chemical equilibria in ideal gases, Real gases at higher pressure (second virial coefficient), General theory of real gases and condensation, and Molecular partition functions of real gases. The third part is on the theory of crystals, Vapour pressure equilibria and Nernst's heat theorem, Cooperative phenomena in crystals—I, Order-disorder transition; II, Matrix theory of the Ising-model; III, Solid solutions. The last four chapters on the theory of fluids are: Pure fluids, Solutions of nonelectrolytes, Solutions of strong electrolytes, and Solutions of macromolecules.

The great majority of the applications involve quantum statistics, although wherever possible the classical solution is treated first. A review of quantum mechanics is included but this is not sufficient for a reader with no knowledge of quantum theory. Similarly, a mathematical appendix gives a considerable number of formulas, definitions, and theorems from complex variable theory,

matrix theory, and the theory of the Laplace transform which in no way serves as an introduction for those readers whose mathematical background is deficient therein. This is in line with the author's intention of writing an advanced textbook for physicists and physical chemists. In this respect the author has certainly succeeded and has given the reader, whose background is adequate and whose interest in the statistical properties of matter is sufficiently intense, an excellent treatise for self study and reference. The careful, logical and complete development of each topic is well worth the reader's effort, particularly if he takes the time to look up and embody some of the numerous references given on almost every page. R. E. Street, USA

1348. Glansdorff, P., and Passelecq, J., Irreversible transformations in the neighborhood of a steady state with constraints characterized by constant currents (in French), *Acad. roy. Belgique, Bull. Cl. Sci.* (5) **43**, 3, 188–194, 1957.

A previous paper [AMR **9**, Rev. 1586] established properties of entropy production of systems subjected to constraints characterized by constancy of temperature and chemical potentials on the boundary surface. These results are now shown to be valid under more general constraints, in which the diffusion current and heat flux (i.e. diffusion and heat currents), or one of the currents and chemical potential or temperature, are given on the boundary surface. B. Gross, USA

1349. Kohler, H., Some thermodynamic formulae and their interpretation, *Ark. Geofys.* **2**, 21, 453–470, Mar. 1956.

This highly theoretical and mathematical paper concerns itself with the rigorous derivation, from basic thermodynamic principles, of the surface tension as a function of the radius of curvature of the "surface of tension." Reference is taken to Willard Gibbs' treatment, based on the concept of thermodynamic potential, and the conditions of equilibrium between the pressure within a droplet and the surrounding vapor pressure are investigated. The paper uses also molecular concepts, and assumes that the droplet grows in a vapor state in which no droplet yet exists, to a size large enough to be in equilibrium with the vapor. In this process the droplet grows from a few molecules to a droplet with a large number of molecules. This view implies that at the beginning of the process the concept of surface tension, as such, has no meaning but it can be regarded as a mathematical equivalent to the intermolecular forces, and therefore surface tension must be defined in terms of statistical thermodynamics.

This profound treatment of surface tension surpasses often the field of engineering, and even that of physics, and transcends into the realm of philosophy. K. J. De Juhasz, Germany

1350. Patterson, G. N., Theory of free-molecule orifice-type pressure probes in isentropic and non-isentropic flows, *Univ. Toronto Inst. Aerophys. Rep.* 41, 14 pp. + 7 figs., Nov. 1956.

Report develops theory for an orifice-type free molecule pressure probe in which orifice diameter is small compared to local mean free path. Work considers monatomic gases utilizing Maxwell velocity distribution for isentropic flow and a velocity distribution function departing by small amount from Maxwellian for non-isentropic flows. Based on development which author suggests, such a probe will measure local speed ratios in isentropic and nonisentropic flows. Author also suggests use in strong shocks for determining viscosity and heat conduction. Reviewer cannot completely agree with this since theory which has been developed is not applicable either to very strong shocks or shocks where relaxation may be present. R. F. Probstein, USA

1351. Sugawara, S., and Sato, T., On the equation of state of high temperature steam, Proc. Sixth Japan nat. Congr. appl. Mech., Univ. of Kyoto, Japan, Oct. 1956, 411–414.

Authors propose a truncated virial expression suitable for description of the volumetric behavior of steam at high temperatures and possibly at high pressures. The empirical evaluation of the coefficients yields results which are reasonably descriptive of experimental data of Kennedy and others. Substantial deviation is reported between the predicted values of the virial coefficients and the values established by experiment. Authors conclude that additional experimental data at high pressures and high temperatures will be required to establish the coefficients of an equation of state describing the volumetric behavior of steam at elevated pressures and temperatures. The virial expressions are employed to establish the influence of state upon the enthalpy and entropy of steam at temperatures up to 1500 K for pressures to 24 kg/cm². The equations presented are a reasonable representation of the available experimental data but illustrate the difficulties of extrapolation into regions where experimental data are sparse.
B. H. Sage, USA

1352. Barron, T. H. K., and Morrison, J. A., On the specific heat of solids at low temperatures, *Canad. J. Phys.* **35**, 7, 799–810, July 1957.

The temperature dependence of the specific heat of solids at very low temperatures is examined, using theoretical models and certain recent experimental results. The temperature region over which the continuum approximation ($C_v = aT^3$) is strictly reliable is shorter than has often been supposed, and the series expansion $C_v = aT^3 + bT^5 + cT^7 + \ldots$ is needed for the analysis of accurate experimental results. For insulators, θ_0 can best be estimated from measured specific heats by plotting C_v/T^3 versus T^2; the result is a curve whose intercept at $T^2 = 0$ gives the coefficient of T^3 (and hence θ_0), and whose slope and curvature give additional information about the vibrational spectrum at low frequencies. For metals, the usual plot of C_v/T versus T^2 can be used, but here again neglect of curvature may lead to errors in the estimates of γ and θ_0. A brief discussion is given of the low-temperature specific heats of a number of solids for which suitable data are available: potassium chloride, lithium fluoride, white tin, tungsten, the noble metals, and elements of diamond structure.
From authors' summary

1353. Powell, D. A., An apparatus giving thermogravimetric and differential thermal curves simultaneously from one sample, *J. sci. Instrum.* **34**, 6, 225–227, June 1957.

A description is given of modifications to a Chevenard thermobalance which enable it to record simultaneously, but on separate charts, both thermogravimetric and differential thermal curves of a single sample undergoing thermal decomposition. A method of placing temperature marks on both charts is also described. Some records obtained and the performance of the apparatus are briefly discussed. From author's summary

1354. Vegh, E., Measuring moisture in gaseous materials (in Hungarian), *Mérés és Automatika* **4**, 10, 294–299, Oct. 1956.

Author treats the absolute, relative, and specific moisture of gases and indicates the relation between them. He briefly sums up the measuring methods used until now and deals more fully with the psychrometric procedure. He shows the measuring accuracy of the various methods and how to carry out the control and the calibration of the instruments. From author's summary

1355. Grant, W. L., An instrument for the measurement of high humidity, *So. African Counc. sci. indus. Res.*, 27 pp., Jan. 1956.

An instrument which will cover a wide range of air humidity measurements, but which is particularly suitable for the measurement of high humidities, is described in this paper. This instrument, which may be called the heated psychrometer, employs wet- and dry-bulb thermometers as measuring elements. The air, of which the humidity is to be measured, is drawn through the instrument at a constant rate, and on passing through is heated to

such a value that the difference between the wet- and dry-bulb temperatures after heating reaches a preset value. It is shown that for an instrument working on this principle the wet-bulb temperature as measured is a unique function of the dew point temperature, and is independent of the dry-bulb temperature, provided the humidity falls within the "control range," i.e., the humidity is so high that the air has to be heated in order to obtain the preset temperature difference between the wet- and dry-bulb elements. For humidities falling outside the "control range" the instrument functions as a normal psychrometer, though in the "control range" the sensitivity of the instrument is higher than that of the ordinary psychrometer, especially at low temperatures. The test results show that the heated psychrometer when properly constructed and carefully used can measure the dew point to ±0.2 F, if the humidity falls within the "control range." The experimental results fall very close to the theoretically determined curves, so that the instrument appears to be very suitable for the measurement of high humidities. From author's summary

1356. Foster, G. A. R., The effect of moisture upon the accuracy of capacity-type regularity testers, *J. Text. Inst., Proc.* **48,** 4, T109–T127, Apr. 1957.

Measurements of the effect of relative humidity upon the deflection of two capacity-type regularity testers have shown that for cotton the effect is so large that, unless suitable precautions are taken, serious errors may arise in the measurement of coefficients of variation. Observations of the rate of diffusion of moisture into yarn and roving bobbins and into cans of sliver, however, have enabled a fairly simple procedure to be devised, which should insure that the error in the coefficient of variation is less than 5% of the coefficient. For Fibro, the effect of moisture is less than for cotton; but, since Fibro materials are often more regular, similar precautions are advisable. No measurements have been made on other fibers. From author's summary

1357. Vinen, W. F., Mutual friction in a heat current in liquid helium II. I. Experiments on steady heat currents, *Proc. roy. Soc. Lond.* (*A*) **240,** 1220, 114–143, Apr. 1957.

Experiments have been carried out on the conduction of heat through helium II in channels of large rectangular cross section ($\sim 2 \times 6$ mm) for small heat current densities. The observed relationship between temperature gradient and heat-current density can be interpreted phenomenologically in terms of the Gorter-Mellink (1949) mutual friction force,

$$F_{sn} \approx A\rho_s\rho_n(v_s - v_n)^3$$

per unit volume, in the two-fluid model, and observed values of A have been found to agree fairly well with those deduced from earlier measurements. Evidence is presented to show that the magnitude of the mutual friction is determined entirely by the value of $(v_s - v_n)$, independently of the boundary conditions imposed on the flow. A study of the propagation of second sound across the heat currents has shown that, while the presence of the heat current leads to no observable change in the velocity of the second sound, it does lead to an attenuation; the attenuation is linear and approximately proportional to the square of the heat-current density. This behavior can be described phenomenologically in terms of the two-fluid model, if it is assumed that, in the presence of both a steady heat current and a second sound wave, the Gorter-Mellink mutual friction must be generalized to the form

$$\mathbf{F}_{sn} = A\rho_s\rho_n \mathbf{U}^2\mathbf{u},$$

where $\mathbf{u}$ is the instantaneous relative velocity between the two fluids and $\mathbf{U}$ is the time average of this relative velocity. This result shows that, in the presence of a steady heat current, one or both of the fluids must become modified in some way, and that an essentially linear mutual friction is associated with this modification. Observation of changes in the attenuation of second sound provides a more sensitive method of measuring mutual friction than does the observation of temperature gradients, and it has been shown by the former technique that in the channels used in the present work there is a critical heat current below which the mutual friction is either absent or very small.

From author's summary

1358. Bach, K., Are heat pumps economical? (in German) *Kältetechnik* **9,** 8, 226–230, Aug. 1957.

1359. Gysin, W., Heat pump applications, *Kältetechnik* **9,** 8, 230–232, Aug. 1957.

1360. Kubli, H., Heat pumps for heating purposes, *Kältetechnik* **9,** 8, 233–237, Aug. 1957.

1361. Lieding, F., A new arrangement for a combined refrigeration and heat pump installation, *Kältetechnik* **9,** 8, 244–246, Aug. 1957.

1362. von Cube, H. L., Utilization of solar energy for heat pumps, *Kältetechnik* **9,** 8, 246–248, Aug. 1957.

Heat and Mass Transfer

(See also Revs. 1230, 1240, 1241, 1254, 1357, 1362, 1389, 1393, 1402, 1423, 1424, 1425)

1363. Lachenbruch, A. H., A probe for measurement of thermal conductivity of frozen soils in place, *Trans. Amer. geophys. Un.* **38,** 5, 691–697, Oct. 1957.

Field measurement of thermal conductivity of nonmetallic substances (such as frozen soils and ice) by thermistor probe is presented and well illustrated. Accurate mathematical method for reduction of obtainable data is shown with numerous references, including the Van der Held and Van Drunen theory. The entire treatment is a competent and practical contribution to the urgent exploration and exploitation efforts in cold regions.

C. R. Bell, USA

1364. Scott, R. F., An hydraulic analogue computer for studying diffusion problems in soil, *Geotechnique, Lond.* **7,** 2, 55–72, June 1957.

Theory, design, operation, and accuracy of computer are described clearly. Design emphasizes solution of nonlinear transient heat-conduction problems with phase changes, time- and space-varying thermal properties, and time-varying boundary conditions. Expecially interesting to reviewer is treatment of latent heats of phase changes. Comparisons of computer results with analytical results for certain simple problems indicates computer accuracy adequate for most engineering applications is obtainable.

Reviewer suggests that need for variable hydraulic resistances (simulating variable thermal conductivity) is eliminated in many problems if one uses, instead of temperature, a variable ϕ related to temperature T and thermal conductivity k by $\phi = \int_{T_0}^{T} (k/k_0)\,dT$.

Then both variable thermal conductivity and variable heat capacity are simulated by appropriately designed hydraulic capacitors [AMR **10,** Rev. 3432]. E. L. Knuth, USA

1365. Crank, J., Two methods for the numerical solution of moving-boundary problems in diffusion and heat flow, *Quart. J. Mech. appl. Math.* **10,** 2, 220–231, May 1957.

Diffusion from a well-stirred bath of given thickness into slab of finite thickness, placed symmetrically in well-stirred bath is

equivalent to freezing of molten slab in finite mold of infinite conductivity. Slab initially at or above melting point. Two methods of solution by finite differences are shown, both requiring successive approximations. First method involves transformation of variable to work with fixed boundary; second uses Lagrangian interpolation formulae to develop finite difference approximations to space derivatives of temperature.

V. Paschkis, USA

1366. McNall, P. E., Jr., and Janssen, J. E., An electrolytic analog applied to heat conduction within a transistor, *Trans. ASME* **78,** 6, 1181-1186, Aug. 1956.

Authors study temperature distribution within a germanium-indium transistor enclosed within aluminum housing with particular reference to determination of temperature drop in the conduction path from the heat-producing function to the transistor housing and the determination of localized hot-spots by use of electrolytic-tank analog. Essential content comprises brief summary of certain pertinent references, details of construction of tank analog and associated instrumentation, discussion of properties of electrolytes used, outline of test procedure, remark of data analysis and discussion of test results, consideration of possible errors, experimental investigation of interface errors, and comparison of the latter data with well-agreeing calculated values. Paper is well written and content should be of value to all interested in transistor characteristics, circuitry, and applications.

T. J. Higgins, USA

1367. Lesem, L. B., Greytok, F., Marotta, F., and McKetta, J. J., Jr., A method of calculating the distribution of temperature in flowing gas wells, *J. Petr. Technol.* **9,** 6, 169-176, June 1957.

The temperature distribution studied is the vertical profile of flowing gas in the bore hole. Because of the geothermal gradient (assumed constant in this analysis), the temperature of gas reservoir is considerably above the surface temperature. The warm gas, flowing up the well, heats up the surrounding earth. Since it may take weeks to approach steady state, transient conditions must be included.

The treatment tacitly assumes that the only significant resistance to heat transfer occurs in conduction through the earth. Other assumptions which are noted include one-dimensional flow, constant linear velocity in the well, constant volumetric heat capacity, and neglect of vertical heat conduction. Analysis includes derivation of dimensionless differential equations, their solution in terms of Laplace transforms, complex integration to give the inverse form, and numerical evaluation of the resulting integrals. Dimensionless plots of the necessary integrals are presented for a wide range of the parameters. Two examples describe a completely dry well and a well with liquid entrained in the gas. In the second, changes in the degree of vaporization naturally result in a high effective heat capacity. The example demonstrates how this heat capacity can be estimated from transient surface temperature data.

Reviewer feels that this is a successful analysis of a real practical problem, since the assumptions do not seem to be especially limiting. Unfortunately, the writeup devotes too much time to mathematical analysis. Since the method is perfectly straightforward, reviewer thinks that a good many of the equations could have been omitted. This would have made it possible to include more examples and discuss the ones given in more detail.

R. R. Hughes, USA

1368. Eckert, E. R. G., and Irvine, T. F., A new method for the measurement of the Prandtl number and heat conduction coefficient of gases (in German), *Forsch. Geb. Ing.-Wes.* **23,** 3, 91-94, Feb. 1957.

The Prandtl number of gases is not known at all accurately from measurements of viscosity, specific heat, and thermal conductivity because of the difficulty of measuring the two thermal properties. However, the temperature recovery factor (i. e., the ratio of the excess of the "eigentemperatur" taken up by a surface along which the gas streams at high velocity above the static temperature to the excess of the total temperature above the static temperature) is a known function of the Prandtl number, and so measurements of it can be used to derive the Prandtl number. The experiments have been carried out for air at atmospheric pressure over the range 15C-180C and give satisfactory results so that the method can be applied to other conditions with confidence.

M. W. Thring, England

1369. Gosse, J., and Poncin, M. H., Study of forced convection across a wire at low Reynolds numbers (in French), *Publ. sci. tech. Min. Air, France,* no. 322, 89 pp., 1956.

The inadequacies of King's law for the forced cooling of a heated wire at low Reynolds numbers are investigated experimentally. Allowance for finite wire length is made, and it is shown that for electrically heated platinum wires the variations of electrical and thermal conductivities with temperature along the wire are usually compensatory. Three regimes of heat loss are distinguished, and empirical laws describing the variation of heat loss with Reynolds number are determined for the Stokes and vortex-street regimes. These results are somewhat similar to those described by Collis [*J. aero. Sci.* **23,** 7, 697-698, July 1956], though the molecular effects described there are not noted. Turbulence and free convection effects are briefly touched on. Further information on the free convection effect will be found in Collis and Williams [AMR **8,** Rev. 2885]. Paper gives a lot of experimental results, but frequent dimensional presentation makes it unduly long.

A. F. Pillow, Australia

1370. Ko, S. Y., and Sogin, H. H., Laminar mass and heat transfer from ellipsoidal surfaces of fineness ratio 4 in axisymmetrical flow, *Trans. ASME* **80,** 2, 387-390, Feb. 1958.

1371. Plapp, J. E., The analytic study of laminar boundary-layer stability in free convection, *J. aero. Sci.* **24,** 4, 318-319, Apr. 1957.

1372. Grassman, P., and Kopp, J., On the choice of temperature difference and heat-transfer coefficient in heat exchangers (in German), *Kältetechnik* **9,** 10, 306-308. Oct. 1957.

The surface of heat exchangers for low temperatures is most efficiently used if the temperature difference ΔT between the two gases is nearly proportional to the absolute temperature T. The work spent on moving the gas becomes relatively small if the velocities and the diameters of the tubes are chosen in such a way that the heat-transfer coefficient α increases with decreasing temperature.

From the author's summary

1373. Fortier, A., Pressure drop and heat exchange in channels (in French), *Chaleur et Industrie* **38,** 382, 115-133, May 1957.

1374. Kayan, C. F., Performance prediction for a process heat-and-power complex by resistance concept, ASME Semiann. Meet., San Francisco, Calif., June 1957. Pap. 57-SA-16, 8 pp.

1375. Stephan, K., Cooling process by means of adiabatic gas expansion (in German), *Kältetechnik* **9,** 10, 314-318, Oct. 1957.

Based on a recent paper of H. Glaser, author investigates a process for the production of cold at constant temperature by means of adiabatic gas expansion. The influence of the efficiency of the engines and the influence of finite temperature differences in the heat exchanger are considered. The process proves to be efficient, if the cold is required at temperatures between −70C-230C. A maximum of efficiency is obtained at a fixed pressure

ratio. The efficiency may be considerably improved if the adiabatic expansion is accomplished in two steps.

From author's summary

1376. Kaye, J., and Elgar, E. C., Modes of adiabatic and diabatic fluid flow in an annulus with an inner rotating cylinder, ASME-AIChE Heat Trans. Conf., University Park, Pa., April 1957. Pap. 57-HT-14, 11 pp.

A valuable aid for designers of electrical machines is offered in the paper, which examines the fluid flow in an annulus formed by two concentric cylinders with the inner in rotation and the outer fixed as at most electrical machines. A new ingenious experimental method is described for vertical and horizontal annuli using a transparent cylinder for visual (photographic) and a set of hot-wire anemometers for oscillographic observations.

By an air inlet on one end of the annulus and a transparent section on the other end, the moment of instability and formation of Taylor vortices can be observed, if axial air velocities are superimposed at the various rotative speeds. The diabatic-flow studies are not yet finished, but preliminary results are given in the form of a three-dimensional surface, the two horizontal axes being the Reynolds and Taylor numbers and the vertical the Nusselt number.

The results of adiabatic and diabatic flow studies have demonstrated the existence of four modes of flow depending on the Reynolds and Taylor numbers: 1-purely laminar flow, 2-laminar flow plus Taylor vortices, 3-purely turbulent flow, 4-turbulent flow plus vortices. The demarcation lines obtained for these four flow regions show excellent agreement with some of the theoretical and practical results of previous investigators.

The conclusion from the studies is that if vortices are present in the air gap of the electrical machine at design operation, then the heat-transfer rates are strongly dependent on the speed of rotation. If the flow is either purely laminar or purely turbulent, then the heat-transfer rate is less dependent on the speed. If vortices are present, then under some conditions it is possible to decrease the heat-transfer rate by increasing the axial velocity of air through the gap.

The results of further investigations in the case of diabatic flow heat-transfer are awaited with much interest.

A. B. Lenkey, Austria

1377. Staniszewski, B., Heat transfer during nucleate boiling of liquids under conditions of natural convection, *Bull. Acad. Polonaise Sci. Cl. (IV)* **5,** 2, 103-105, 1957.

Test data were taken, but are not presented in the paper, for pool boiling of degassed-distilled water, trichlorethylene, and carbon tetrachloride on a platinum wire. The water data agreed with data of Addoms (see McAdams, 3rd edition, p. 382) and was correlated in the following equation [Roshenow, *ASME Trans.* 1952, p. 969]

$$\frac{c_l \Delta T}{b_{Fg}} = C_{SF}\left(\frac{q/A}{\mu_l b_{Fg}}\sqrt{\frac{g\sigma}{g(\rho_l-\rho_v)}}\right)^{0.33}(N_{Pr,l})^{1.7}$$

with $C_{SF} = 0.0143$.

No mention is made of the correlation for the other two fluids tested.

Defining the heat flux at transition from nucleate to film boiling as q_I and from film to nucleate boiling as q_{II}, author's test data for trichlorethylene in pool boiling on a platinum wire suggest the following equations:

$$\frac{q_I}{b_{fg}\,p^{0.39}} = 2900$$

$$\frac{q_{II}}{b_{fg}\,p^{0.39}} = 600$$

where q = heat flux, kcal/m²h; b_{fg} = latent heat, kcal/kg; p = pressure, ATA. No data points nor graphical results are shown.

W. M. Rohsenow, USA

1378. Griffith, P., The correlation of nucleate boiling burnout data, ASME-AIChE Heat Transfer Confer., University Park, Pa., Aug. 1957. Pap. 57-HT-21, 17 pp.

1379. Haussler, W., Temperature profiles on both sides of an evaporating water surface Parts I, II (in German), *Technik* **12,** 1, 3-6, Jan. 1957; **12,** 2, 66-74, Feb. 1957.

The experiments using resistance thermometers of the author's own design have made it clear why previous experiments on cooling towers did not confirm Lewis' theory. A possible starting point for future research is seen in Merkel's experiments [*VDI-Forsch.* no. 275, 1925]. The temperature gradient within the water can be correlated to the wet-bulb temperature and to the air velocity. Lines of constant "adiabatic state of equilibrium" in the Mollier chart are discussed.

From author's summary by W. Gumz, Germany

1380. Christian, W. J., and Kezios, S. P., Experimental investigation of mass transfer by sublimation from sharp-edged cylinders in axisymmetric flow with laminar boundary layer, Heat Trans. and Fluid Mech. Inst., Calif. Inst. Technol., Pasadena, Calif., June 1957, 359-381.

An experimental investigation was performed on the mass transfer by sublimation from the outer surface of a hollow naphthalene cylinder in a uniform air stream. The axis of the cylinder was parallel to air stream. Uniform external flow at the upstream end was maintained by sharpened leading edges and by an independent control of the internal flow. Local mass transfer was determined by physical measurement of the cylinder diameter. Experimentally determined local mass-transfer coefficients were compared with various analytical solutions for the local drag coefficient. Differences between the experimentally determined mass-transfer coefficients and the analytically determined drag coefficients were attributed to the effect of surface curvature on the analogy between skin friction and mass transfer.

M. R. Carstens, USA

1381. Traupel, W., Transmission of heat and thermal cycles in atomic power stations (in French), *Bull. tech. Suisse Rom.* **82,** 22, 401-410, Oct. 1956.

Paper is a well-organized brief presentation of the elements of the thermal design of nuclear reactors and of the selection of power cycles. Author concludes that Europe will, for now at least, concentrate on natural and slightly enriched fuels, and that adequate thermal efficiencies will be obtainable without high temperatures.

C. F. Bonilla, USA

1382. Kay, J. M., and Hutchinson, F. J., The pressurized water reactor as a source of heat for steam power plants, *Proc. Instn. mech. Engrs.* **170,** 8, 281-306, 1956.

1383. Herrington, L. P., The biotechnical problem of the human body as a heat exchanger, *Trans. ASME* **80,** 2, 343-346, Feb. 1958.

Attention has long been focused on the problems involving human tolerance to heat or cold stress brought about by environments commonly encountered in industry or in deep-level mining. Author demonstrates the applicability of the classical heat-loss equations to the human body when the correct physiological data are used. He has succeeded in reducing the large body of calorimetric data gathered over a lengthy period to fit a statistically-derived empirical equation in five variables to cover a given range of environmental conditions. The use of this equation eliminates

the need for special physiological knowledge on the part of the engineer, and results in a considerable reduction in computational effort.

The derivation of equations for other ranges than the one treated in the paper is awaited. Reviewer would welcome the inclusion of body heat storage as a variable.

J. Visser, South Africa

1384. Meehan, J. P., and Jacobs, H. I., Body cooling and hand cooling, ASME Semiann. Meet., San Francisco, Calif., June 1957. Pap. 57-SA-34, 9 pp.

Experiments to demonstrate the physiological ability of an individual to perform in a cold environment are described. Whole-body cooling, and hand cooling are compared, and it is shown that these cannot be considered separately. Either type results in a peripheral vasoconstriction, the extent of which will play a major role in determining the extent and rate of body skin cooling. The physiological adaptations of the human body to cold are small. Nevertheless, a person familiar with a cold environment can perform his tasks more efficiently than the inexperienced person. This adaptation does not constitute a major change in his physiology. Rather it is an alteration in the interpretation of the cold stimulus by the central nervous system, as well as a modification of the autonomic vasoconstriction seen on exposure to cold, which accounts for his apparent improvement in cold performance.

Paper is a valuable contribution to knowledge of the physiological reactions and adaptations of workers to colder climates.

J. Visser, South Africa

1385. Woodcock, A. H., Breckenridge, J. R., Pratt, R. L., and Powers, J. J., Jr., Analysis of energy exchange between man and his environment, ASME Semiann. Meet., San Francisco, Calif., June 1957. Pap. 57-SA-64, 5 pp.

Considerable study has gone into the finding of an index of warmth for the human body which would cover all the environmental factors involved. Several scales have been proposed and used to a greater or lesser extent, depending on the climate to which each is best suited. Author believes that considerable progress can be made toward obtaining an index of warmth by applying the physical laws of heat exchange. After treating the general laws for the three modes of energy exchange, viz., convection, radiation, and evaporation, they are applied to the human body. Examples are given of the utilization of these equations to calculate the limits of temperature and humidity under which man can maintain thermal equilibrium for a given heat production. Both "dry-skin" and excess-sweat conditions are treated. It is interesting to note that this treatment yields an equation similar to Hills' empirical relationship for the wet bulb index under hot, humid conditions.

Author concludes that variations in skin temperature, air movement, and sweat rate over different areas of the body complicate the mathematical treatment. To be of use, any physical analysis must be modified by the biotechnologist on the basis of his skill and judgment, supported by laboratory data.

J. Visser, South Africa

1386. Hendler, E., Crosbie, R., and Hardy, J. D., Measurement of the heating of the skin during exposure to infrared radiation, ASME Semiann. Meet., San Francisco, Calif., June 1957. Pap. 56-SA-33, 8 pp.

An equation is derived for the change in surface temperature of the human skin when exposed to non-penetrating, i.e. long-wave, radiation.

Experimental data are presented from a sensitive apparatus in which the test surface is heated or cooled, and its surface temperature measured accurately by radiometer. Tests were conducted on an inert substance, masonite, and on unblackened living human skin. Values of the product "specific thermal conductivity × density × specific heat", which expresses the important factor of thermal inertia of the test substance, are given. For living human skin of subjects at rest in normal room environments, this product was calculated to be

$$111 \times 10^{-3}\ \text{cal}^2/(\text{cm}^4)(^\circ\text{C}^2)(\text{sec})$$

An important feature of the experimental procedure is the mild heating involved, which makes it applicable to other studies such as cutaneous blood-flow measurements, the relationships between temperature sensation and temperature, and the derivatives of the latter with respect to time.

J. Visser, South Africa

1387. Tischer, R. G., and Hurwicz, H., Heat transfer in the food industry, ASME Semiann. Meet., San Francisco, Calif., June 1957. Pap. 57-SA-65, 5 pp.

Combustion

(See also Revs. 1239, 1321, 1390)

1388. Friedman, R., and Grover, J. H., Tenth annual unit processes review: Combustion, *Indust. Engng. Chem.* **49,** 9 (Part II), 1470–1477, Sept. 1957.

Annotated bibliography of current research on theory of laminar flame propagation, burning-velocities measurement techniques and their results (with a tabulated list of combustible systems other than hydrocarbon-oxygen), laminar flame structure, flammability limits, wall quenching, chemical extinguishment, combustion-flow interaction, and gaseous detonation, covering the period of 1953 to end of 1956 (with 248 references, including 21 books and reviews).

Combustion of solid fuel in boiler and industrial furnaces is not considered.

From authors' summary by W. Gumz, Germany

1389. Spalding, D. B., A theory of inflammability limits and flame-quenching, *Proc. roy. Soc. Lond.* (*A*) **240,** 1220, 83–100, Apr. 1957.

The mathematical treatment of a simple flame is given. Heat loss from flame to surroundings is introduced and the heat and mass balance equations solved for constant gas properties. Heat loss is assumed to arise only downstream of reaction zone as consequence of chemical heat generation having greater temperature dependence than does heat loss. Solution indicates existence of two flame speeds for each value of heat loss below a greater level. Latter is assumed to correspond to inflammability limit. For flames inside ducts, equations also give quenching Peclet number equal to 60, compared with 45 experimentally.

Author concludes only higher of the two flame speeds is stable; also that value is finite at inflammability limit. Nature of physical model tends to restrict treatment to flames of appreciable activation energy. Reviewer believes paper provides reasonable model for inflammability limits. However, some experimental evidence given by author on double-valued flame speed for heat loss to a porous plate suggests that the model may be incomplete.

M. Gilbert, USA

1390. Pinkel, I. I., Weiss, S., Preston, G. M., and Pesman, G. J., Origin and prevention of crash fires in turbojet aircraft, *NACA TN* 3973, 65 pp., May 1957.

1391. Knight, H. A., and Walker, R. B., The component pressure losses in combustion chambers, *Aero. Res. Counc. Lond. Rep. Mem.* no. 2987, 34 pp., 1957.

Report summarizes the available knowledge of the component losses in a combustion chamber. The information given should

enable the pressure drops through swirlers, primary baffes, cooling systems, etc., to be calculated. Most of the data were abstracted and collected from the various reports listed in the bibliography. In certain cases (*e.g.*, mixing losses) the information is incomplete and in these circumstances the limited experimental results available are supplemented by hypotheses which require proof. A specimen calculation of the pressure drop and airflow distribution of a typical chamber is given in Appendix II. The calculated and measured values of pressure drop (cold) agreed within 4 per cent. From authors' summary

1392. Fraser, R. P., High intensity combustion in chemical engineering, *Trans. Inst. Chem. Engrs.* **35,** 3, 219–243, 1957.

Significance and advantage of burning fuels at high volumetric heat-release rates are discussed with reference to applications in chemical engineering. Maximum theoretical rate of combustion is considered and the comparative volumetric heat release rates of industrial and other equipment are compared. Recent designs of combustion chambers for both gaseous and liquid fuels are given and classified according to use. Some results of combustion with liquid fuels below stoichiometric proportions are given, and it is shown that heavy fuel oil can be burnt to low calorific gas with or without the generation of carbon. Importance and methods of obtaining complete control of the combustion process are emphasized. Future importance of very high velocity oxidation processes for the generation of gases or organic products is mentioned. Tables are given of combustion processes, listing temperature of combustion, total weight of products, volumetric heat-release rate, activation energies, and total momentum.

K. J. De Juhasz, Germany

1393. Coffin, K. P., and Brokaw, R. S., A general system for calculating burning rates of particles and drops and comparison of calculated rates for carbon, boron, magnesium, and isooctane, *NACA TN* 3929, 56 pp., Feb. 1957.

A system with general equations has been devised for computing the burning rates of small particles burning as diffusion flames; the equations account for the effects of diffusion and dissociation with a high degree of rigor. Two types of solutions are carried out: (1) a numerical integration of considerable complexity, and (2) a somewhat less complicated and less rigorous analytical solution involving stepwise iteration across the temperature profile. The direct results of the calculation are partial pressures as a function of temperature. Simple additional calculations produce the burning rate and the flame structure.

Both solutions were obtained for carbon burning in air; the differences are slight. For boron, because of the greater number of equilibria involved, only the analytical solution was undertaken. A number of ambient temperatures and ambient oxygen concentrations were examined in the case of boron; as an example, three graphs rapidly yield burning rates for a wide range of ambient conditions.

The general equations reduce to the much simpler equations used by previous investigators. The simplified equations were also applied to boron, and yielded results in general agreement with the more detailed analytical solutions. The simplified equations appear to be suffiently accurate for many purposes.

For a series of substances covering a wide range of volatility, relative heat-release rates are in the order: hydrocarbon > magnesium > carbon ≅ boron.

From authors' summary by G. K. Adams, England

1394. Foilden, G. B. R., Thorn, J. D., and Kemper, M. J., A standard gas turbine to burn a variety of fuels, *Proc. Instn. mech. Engrs.* **170,** 20, 665–696, 1956.

Two aspects of gas-turbine design and operation are dealt with. First, an account is given of the development of special types of "kinematic" construction suitable for accommodating the very large temperature changes encountered when a gas turbine is started and put on load rapidly. Examples are given of the application of this type of construction to represenative components of a 750–1000-kW gas turbine.

Secondly, a description is given of the development of combustion chambers to burn fuels ranging from natural gas and gas oil to residual fuels, coal tar fuel and peat. A range of chambers to burn these fuels has been designed to fit interchangeably on the basic components of the standard turbine. A detailed account is given of the development of a combustion chamber of elbow type which takes advantage of the fact that a number of changes of direction through 90 deg or more are necessary in the ducting of nearly all industrial gas turbines. Development of this chamber is described from early atmospheric test models to the final pressurized combustion chambers which have been fitted to production gas turbines. With only slight adjustments, this type of chamber has shown itself capable of burning hydrocarbon fuels, ranging from natural gas to residual fuel oils, and a modified form of chamber has also successfully burnt low calorific value gases.

From authors' summary

1395. Kalosbrior, N. A., Rudman, V. D., and Klezles, V. I., The character of the gas flow in the working space of an open-hearth furnace (in Russian), *Sb. nauch. tr. Zhdanovsk. Metallur. in-ta* no. 3, 113–129, 1955; *Ref. Zh. Mekh.* no. 11, 1956, Rev. 7358.

The results of observations on the spectra of the flow in the working space of a soaking pit are described. The flow spectra were obtained by the method of tufts, well known in aerodynamical research. The tufts were suspended in a frame, movable over the different cross sections of the working space.

The observations were conducted for an open-hearth furnace of the Azovstal works, equipped with two-stage heads. The test model was made of an organic glass, to a scale of 1:20. The experimental Reynolds' number was greater than 100,000.

The test results were compared with the results of similar tests made earlier in the Moscow Steel Institute on hydraulic and aerodynamic analogs in which the motion of the gases was indicated by dye or powder (smoke) introduced into the flow.

I. E. Idel'chik

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

1396. Molchanov, K. K., On gas flow and combustion in light-fuel engines (in Russian), *Trudi Mosk. avtomob.-dor. in-ta* no. 17, 85–100, 1955; *Ref. Zh. Mekh.* no. 11, 1956, Rev. 7391.

Paper investigates the air currents and combustion processes in light-fuel (spark ignition) internal-combustion engines to elucidate the nature of the change in indicated efficiency with increasing compression ratio.

Measurement of the velocities and flow pulsations was performed by means of hot-wire anemometers with a tungsten wire of 19-microns diam and 4.5-mm length, with the engine motor cold. A considerable increase in the rate of turbulent pulsation was observed when the form of the combustion space was varied.

Flame propagation was recorded by means of a movable ionization chamber and enabled a marked relationship to be established between the flame velocity and the compression ratio in the first part of the flame path, in which about 5% of the charge volume is burnt; and a lesser relationship of the flame velocity during burning of the principal mass of the charge.

Experimental data have been obtained on the change in indicated efficiency with increasing compression ratio.

M. A. Peshkin

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

Acoustics

(See also Revs. 1131, 1218, 1221)

1397. Ting, L., Diffraction of disturbances around a convex right corner with applications in acoustics and wing-body interference, *J. aero. Sci.* **24,** 11, 821-830, Nov. 1957.

Author formulates title problem, assuming incident pulse of general space, time dependence, as integral equation. Latter is solved by iteration. Comparison with known solution for weak shock indicates two steps of iteration are usually sufficient. Results are applied to diffraction of weak shock by rectangular barrier and to supersonic, wing-body interference for fuselage of rectangular cross section.

J. W. Miles, USA

1398. Whitmarsh, D. C., Skudrzyk, E., and Urick, R. J., Forward scattering of sound in the sea and its correlation with the temperature microstructure, *J. acoust. Soc. Amer.* **29,** 10, 1124-1143, Oct. 1957.

Scattering measurements are compared with predictions of existing theories. Agreement is satisfactory. Measurements of temperature microstructure, however, lead to unexpected results, showing that patch sizes or scales of patch sizes are continuously distributed and that temperature fluctuation increases continuously with range. There seems to be almost perfect agreement with results of theory of homogeneous turbulence and temperature fluctuations in water. This would appear to invalidate present theories, since a correlation function as defined in the usual sense does not exist. If, however, the correlation function is replaced by a new function in connection with a suitably defined temperature distribution, practically all the results of the current theory can be shown to remain valid, and it becomes possible to explain other items which hitherto had not been understood. Acoustically effective patches turn out to be a function of frequency and range rather than of particular sea conditions.

From authors' summary by G. Power, England

1399. Twersky, V., On scattering and reflection of sound by rough surfaces, *J. acoust. Soc. Amer.* **29,** 2, 209-225, Feb. 1957.

1400. Heaps, H. S., The reflection coefficient of a surface of Rayleigh distributed impedance, *Quart. appl. Math.* **15,** 3, 291-297, Oct. 1957.

Formulas are obtained for the probability distribution $P(k)$ of the amplitude k of $(z-c_2)^2(z+c_1)^{-2}$ in which c_1 and c_2 are real constants. z is a complex number of the form $c+z_1$ where c is a complex constant and z_1 is a complex variable of Gaussian distribution of amplitude and uniform distribution of phase. Above relation between k and z arises when $c_1=c_2$ in connection with the reflection of a plane wave of sound from a plane surface, and relates to power reflection coefficient k to the acoustic impedance ratio z. Author expresses $P(k)$ in terms of modified Bessel functions I_0 and I_1 if c is real, and in terms of gamma function if c is complex. Asymptotic formulas are included to allow calculation of $P(k)$ beyond the range of tabulation of modified Bessel and incomplete gamma functions. Simplifications are introduced when k is small or close to unity. Reference is made to research by P. M. Morse, R. A. Scott, G. D. Monteath, S. A Schelkunoff, H. S. Heaps, G. N. Watson.

J. J. Polivka, USA

1401. Bratt, M. J., Uses of statistical methods for ultrasonic inspection problems, *Nondestructive Testing* **15,** 5, 282-287, Sept./Oct. 1957.

1402. Bhatia, A. B., Sound and ultrasound absorption resulting from heat radiation, *J. acoust. Soc. Amer.* **29,** 7, 823-824, July 1957.

Following a suggestion by Markham, Beyer, and Lindsay, the Stefan-Boltzmann radiation law is applied to estimate the attenuation of approximately plane compression waves resulting from heat radiation. The attenuation is found to be independent of the frequency of the compression waves in the entire relevant frequency range and inversely proportional to a linear dimension of the wave fronts. At ordinary temperatures, this attenuation is negligible compared to that due to thermal conduction and viscosity, verifying the results of Rocard and Rayleigh. In gases at temperatures of 1000 K or more, however, the attenuation due to heat radiation is not entirely negligible under certain conditions.

From author's summary

1403. Hashimoto, T., and Kikuchi, Y., Ultrasonic propagation measurement in sea water up to 400 kc, *J. acoust. Soc. Amer.* **29,** 6, 702-707, June 1957.

The propagation characteristics of ultrasound in sea water and its ultrasonic reflection loss on the sea bottom or on fish schools must be studied for both the design and the practical operation of echo sounders, fish finders, and SONAR's. This paper shows a practical method for this study, together with the results of measured propagation characteristics in both vertical and horizontal directions, as well as the ultrasonic reflection loss on the sea bottom and on fish schools, using 28, 50, 200, 300, and 400 kc.

The propagation attenuation in a direction vertical to the sea surface is the result mainly of spherical divergence, but the attenuation in a horizontal direction is caused partly by absorption as well. This absorption becomes larger at higher frequencies; in fact, the results of experiments show that the absorption is 10-20 db/km at 28 kc, 37-50 db/km at 200 kc, and about 120 db/km at 400 kc. The reflection loss of the ultrasound at a fish school decreases as frequency increases. On the contrary, the reflection loss of the sea bottom increases as frequency increases. At 200 kc, therefore, the echoes from ground fishes sometimes become stronger than that from the sea bottom.

From authors' summary

1404. Pietrasanta, A. C., Aircraft noise and building design, *Noise Control* **3,** 2, 11-18, Mar. 1957.

1405. Kirchman, E. J., and Greenspon, J. E., Nonlinear response of aircraft panels in acoustic noise, *J. acoust. Soc. Amer.* **29,** 7, 854-857, July 1957.

Paper considers the response of thin elastic plates to sinusoidal acoustic excitation. A theoretical method for obtaining the dynamic deflection and stress in the nonlinear region is given. The theory is compared with test results and shows rather good agreement. The application of the theory to the design of panels to withstand acoustic fatigue is discussed in the latter part of the paper.

From authors' summary

1406. Hickman, J. S., Risty, D. E., and Stewart, Ellen S., Properties of sandwich-type structures as acoustic windows, *J. acoust. Soc. Amer.* **29,** 7, 858-864, July 1957.

The acoustic transmission of a sandwich consisting of a pair of plane parallel solid plates immersed in a liquid has been investigated theoretically and experimentally. Not only the dilatational waves, but also the shear waves, are considered. Results show greatly improved transmission characteristics over those of single thick metal plates with respect to dependence on both frequency and angle of incidence. Theoretical transmission curves for a sandwich of two steel plates have been prepared to exhibit the dependence of transmission on frequency, on ratio of plate thickness to wave length and separation to wave length, and on angle of incidence, respectively. Calculated transmission curves for single steel plates, including half-wave plates, are shown for comparison. An experimental test was made on a steel sandwich

with lateral dimensions of the order of two wave lengths and plate thickness-to-wave-length (in the steel) ratio equal to 0.05. The measured transmission losses are within ±4 db of the calculated values. From authors' summary

Ballistics, Detonics (Explosions)

(See Revs. 1303, 1428)

Soil Mechanics, Seepage

(See also Revs. 1198, 1363, 1417, 1418, 1419, 1420, 1421)

1407. Schneebeli, G., Regarding well hydraulics (in French), *Houille blanche* **12,** 8, 278–283, May-June 1957.

A practical study of the relation of well draw-down for the case of a horizontal layer being drained by a well which penetrates to a lower horizontal boundary, to radius of action. The assumptions are the usual ones of homogeneity, D'Arcy's law, and incompressibility of both fluid and medium. A comparison with Dupuit's solution is made. Author's solution is simple and practical within the same limits that the assumptions impose on most solutions of the problem. K. N. Hendricksen, USA

1408. Soeiro, M. F., Habib, M. P., and Tcheng, M. Y., Some research in the field of soil mechanics, suction, thermo-osmosis and superficial foundations (in French), *Ann. Inst. tech. Bât. Trav. publics* no. 110, 119–144, Feb. 1957.

These are three articles in soil mechanics. Mr. Soeiro discusses the characteristic form of capillary rise curves as affecting the moisture content of different materials. Comments are made on the application of theory in establishment of equilibrum profiles of moisture content beneath foundations in homogeneous or stratified soils.

Mr. Habib gives a summary of laboratory research on thermo-osmosis. Liaison between soil and water, and the possible relationship with electro-osmosis are discussed.

Mr. Tcheng comments on the bearing strength of stratified soils. The results of theoretical and experimental evaluation of bearing strength increased by sand layers over soft clay are compared.
J. A. Cheney, USA

1409. Menard, L., Measuring in situ the physical characteristics of soils (in French), *Ann. Ponts Chauss.* **127,** 3, 357–377, May-June 1957.

Many engineers have thought it desirable that a study be made of a simple method for determining and calculating the carrying strength of a foundation in respect to its subsidence. In order to solve this problem elastic-plastic theories must be applied.

Others have considered it even more desirable to study an apparatus which would permit the very economical measuring *in situ* of the plastic and elastic characteristics of the ground; thus very greatly extending application of ground mechanics into the field of building.

Both these views have led the École nationale des Ponts et Chaussées of Paris, and the University of Illinois (U.S.A.) to determine the conditions for the use of a new apparatus called "pressiometer."

Inside the ground itself of the foundation, this apparatus creates a field of stress and measures the corresponding deformations; analysis of the diagram thus obtained permits to calculate the modulus of elasticity as well as the shearing strength values.

Over 75 experiments, controlled by means of standard tests, have proved the soundness of the theory of the apparatus applied to very different grounds. These experiments have put in focus, particularly for sands, the very important part played by the coefficients of elasticity in foundation problems.

Scope of this article is to present a series of experiments realized in Chicago clays, and to briefly give some theoretical results used to analyze the diagrams.
From author's summary

1410. Akai, K., On the relationship between the stress distribution and the degree of compaction of earth embankments, Proc. Sixth Japan nat. Congr. appl. Mech., Univ. of Kyoto, Japan, Oct. 1956, 229–233.

Using the equation of stress equilibrium at rest in terms of the coefficient of compaction of fill material, author obtains a solution of the stress distribution in earth embankments on a rigid base and corresponding to the given degree of compaction. The measured stress distribution below a model sand dam supports the theoretical relationships. G. G. Meyerhof, Canada

1411. Kharitonov, N. I., and Brezhnev, A. V., The validity of the Frölich equations in the determination of rock stresses (in Russian), *Sb. nauch. tr. Kazakh. gorno-metallurgich. in-ta* no. 9, 358–372, 1954; *Ref. Zh. Mekh.* no. 11, 1956, Rev. 7816.

Starting from the similarity between the diagrams of vertical, normal stress, constructed by the formula of O. K. Frõhlich ["Distribution of soil pressures," Narkomkhoz, RSFSR, 1938] for a semi-plane acted upon at its boundary by a concentrated force, and the Gaussian curves, the authors deduce that the normal stress distribution in the horizontal plane follows a standard law of distribution.

To confirm this assumption, tests were made with a frequency board of 750 × 750-mm dimensions. A grid was plotted on the polished surface of the board, and pegs driven in at the intersection points of the grid lines with a spacing of 22.5 mm. This grid was intended to reproduce the theoretical grid of a semi-plane, on which the stresses were determined for different values of the distribution (concentration) coefficient ν, characterizing the scattering of the stress values.

A ball of 15-mm diameter was released along a line corresponding to the line of action of the applied force, from a distance of 75 mm and with 5, 15, 25, and 35° inclination of the board. The exit of the ball from the board after passing between the pegs was recorded in terms of the number of corresponding abscissa.

About 200 such balls were released at each angle of inclination of the board, and the results evaluated by statistical mathematics.

The distribution of the tangent stresses τ_{zx} was likewise investigated. Comparison of the theoretical curves constructed by the Frõhlich equations with the distribution curves obtained experimentally showed that for any particular depth z from the surface of the semi-plane and for any given value of the index ν, it is possible to select such an angle of inclination of the board as will cause the curve of standard distribution to reproduce the theoretical curve of distribution of the normal stresses.

At certain values of the index ν the results transgress the limits of a two-dimensional problem.

From these investigations, authors have concluded that the Frõhlich equations are applicable to the determination of rock stresses in strata the anisotropic character of which depends on their mineralogical composition and texture, following a statistical law of distribution.

The paper contains misprints.

It should be observed that the application of a Gaussian law of distribution for the investigation of stress distribution in soils has been suggested in another form by G. I. Pokrovsky ["Researches on soil physics. The elementary physics of disperse systems, in application to soils and rocks," ONTI, 1937, 73–82].
G. K. Klein
Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

1412. Murayama, S., and Shibata, T., On the rheological characters of clay, Proc. Sixth Japan nat. Congr. appl. Mech., Univ. of Kyoto, Japan, Oct. 1956, 225–228.

On the basis of structural viscosity derived from statistical mechanics authors develop a formula concerning the deformation of clay. The relationship indicates that creep strain increases with the logarithm of time and linearly with stress below an upper yield value; for greater stresses, creep failure takes place after a certain time, as shown by supporting experimental evidence.

G. G. Meyerhof, Canada

1413. Buachidze, I. M., and Nasberg, V. M., The influence of the diameter of the ideal earthen wall on its yield (in Russian), *Razvedka i okhrana nedr.* no. 2, 42–45, 1955; *Ref. Zh. Mekh.* 1956, Rev. 6086.

The faulty nature of the diagram by Prints [E. Prints, "Gidrogeologiya," Sel'kokhozgiz, 1932] is pointed out; this diagram illustrates the influence of the diameter of the ideal wall on its yield when the determination of the latter is based on Dupuis' formula. The calculations made by the authors show that this diagram, reproduced in a number of textbooks and monographs, agrees with the Dupuis' formula for the range from $d = 0.2$m to $d = 1.0$m, (d = diameter of the wall), but for values from $d = 0$ to $d = 0.1$ is incorrect. Authors recommend the use of the graphs they have constructed following Dupuis' formula, and given in their article, in place of Print's diagram.

V. K. Belyakova

Courtesy Referativnyi Zhurnal, USSR

Translation, courtesy Ministry of Supply, England

1414. Preobrazhenskaya, N. A., Experimental investigations on the vibro-driving of piles and sheet piling (in Russian), *Trudi n.-i in-ta osnovanii i fundamentov* no. 27, 48–57, 1955; *Ref. Zh. Mekh.* 1956, Rev. 5428.

Description of an arrangement by which experimental investigations were made for determining the relationship of the speed of driving-in of the pile to the oscillation conditions of the vibrator and the cross section of the piles. The tests were made in an area having homogeneous soil.

Curves (hodograms) of the relationship of the depth of immersion of the piles and the sheet piling to time are given.

A. F. Rozhnyatovskii, USSR

Courtesy Referativnyi Zhurnal

Translation, courtesy Ministry of Supply, England

1415. Yokoo, Y., and Yamagata, K., On the calculation formulae of differential settlement of structures, Proc. Sixth Japan nat. Congr. appl. Mech., Univ. of Kyoto, Japan, Oct. 1956, 161–164.

Authors extend their previous theoretical study ["A theoretical study on differential settlements of structures," Disaster Prevention Research Institute Bulletin, no. 14, Mar. 1956] to compute differential settlements and total footing reactions of structures, accounting for rigidity of the frame. As in earlier studies [Chamechi, S., "Structural rigidity in calculating settlements," *Proc. Amer. Soc. civ. Engrs.* **81**, SM1, Jan. 1956], the usual simplifying assumptions are made. For substantial, long-term settlements, resulting from the consolidation of clay strata, the assumption that the structure behaves elastically may be questioned.

An example is worked out for a simple symmetrical case.

G. A. Leonards, USA

Micromeritics

(See also Revs. 1146, 1198, 1268, 1367, 1407, 1408)

1416. Schadt, C., and Cadle, R. D., Critical comparison of collective efficiencies of commonly used aerosol sampling devices, *Anal. Chem.* **29,** 864–868, June 1957.

Theories of particle collection techniques, as applied to commonly used instruments, such as sedimentation chambers, mine safety appliances, electric precipitators, Greenburg-Smith impinger, "Millipore" filters, Cassella thermal precipitator, and an impactor. The efficiencies were determined by using monodisperse aerosols, i.e., have particles closely of the same. Marked discrepancy was found between the theoretical and the observed efficiencies; possible reasons for the discrepancy are discussed. Tables and curves of test results are given.

K. J. De Juhasz, Germany

1417. Solekhov, G. S., and Chugunov, V. D., Some problems of control of the motion of the petroleum-bearing contour (in Russian), *Dokladi Akad. Nauk SSSR (N.S.)* **101,** 6, 1013–1016, 1951; *Ref. Zh. Mekh.* 1956, Rev. 5314.

In a circular homogeneous horizontal seam of constant power there are n operational crevices disposed at equal intervals round the circumference of radius ρ_1. In the zone of the limiting water there are also n delivery crevices disposed at equal intervals round a circumference of a radius ρ_2. The viscosity of the water and the petroleum is equal. On the circular supply contour of radius R the pressure is constant. It is necessary to find a relative dispostion of the crevices and a method of their operation in which the petroleum-bearing contour Γ_0 when moving to Γ_1 deviates least from the circumference, on the condition that Γ_0 and Γ_1 are circumferences having radii of r_0 and $r_1 (r_0 > r_1)$.

Putting the law of contraction of a petroleum-bearing contour in the form

$$r^2 = r_0^2 - \frac{t}{T}(r_0^2 - r_1^2)$$

author shows that the disposition of the crevices should be a staggered circular one, and the discharge of the pressure crevice is determined by the equation

$$q^2 = \frac{V_0}{nT}\left(\frac{\rho 1 \quad \rho 2}{r^2}\right)^n$$

where V_0 is the volume of the petroleum subject to expulsion, t is the time, and T is the full period of operation. The results obtained are generalized for the case of two operational batteries, in each of which there are n crevices, and for the case of three circular batteries, of which two are operational and one is a delivery one.

The example is examined on the condition that the total discharge of the crevices of the operational batteries remains constant for the whole period of operation.

P. F. Fil'chakov

Courtesy Referativnyi Zhurnal, USSR

Translation, courtesy Ministry of Supply, England

1418. Solekhov, G. S., Statement of and methods for solving hydrodynamic problems of control of the motion of the petroleum-bearing contour (in Russian), *Dokladi Akad. Nauk SSSR (N.S.)* **101,** 5, 809–812, 1955; *Ref. Zh. Mekh.* 1956, Rev. 5313.

The following problem is put: a plane seam having a permeability of k = const is saturated with water and petroleum, and separated with a single link contour "(petroleum-bearing contour)." Assuming the given law of contraction of the petroleum-bearing contour, it is necessary to determine that displacement of the

crevices and that method of their operation which, within the limits of the practical possible variation of the parameters φ_i, ρ_i, q_i (φ_i is the polar angle, ρ_i is the polar radius, q_i is the volume discharge of the i'th crevice), would insure by the best method the required law of contraction of the petroleum-bearing contour. In order to solve the problem it is suggested that the nonlimiting conditions should be used, which should be satisfied by the function $F(t, r, \theta) = 0$, which determines the mobile boundary Γ of the deviation of the liquids

$$p^+ | \Gamma = p^- | \Gamma; \frac{k}{\mu_H} \frac{\partial p^+}{\partial n} \Gamma = \frac{k}{\mu_B} \frac{\partial p^-}{\partial n} | \Gamma \qquad [1]$$

$$m \frac{\partial F}{\partial t} - \frac{k}{\mu_H} \left(\frac{1}{r^2} \frac{\partial p^+}{\partial \theta} \right)_\Gamma \frac{\partial F}{\partial \theta} - \frac{k}{\mu_H} \left(\frac{\partial p^+}{\partial r} \right)_\Gamma \frac{\partial F}{\partial r} = 0 \qquad [2]$$

In this, m is the porosity of the seam, r and θ are the polar coordinates, and p^+, p^- is the pressure on the contour Γ in the petroleum and water regions.

Putting $F(t, r, \theta) = r - f(\theta, t)$ in Eq. [2] and making p^+ dependent on φ_i, ρ_i, q_i, θ, and r, we find that the right-hand portion of Eq. [2], generally speaking, will differ from zero, forming ϵ. The parameters φ_i, ρ_i, q_i should be determined by the method of imaginary error in the approximation of Eq. [2]. The conditions in which this problem can be solved are not considered in the paper.

V. P. Pilatovskii

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

1419. Chugunov, V. D., Control of the petroleum-bearing contour in the case of elastic conditions of petroleum deposits (in Russian), *Izv. Kazansk. fil. Akad. Nauk. SSR, Ser. fiz-matem. i tekhn. Nauk.* no. 8, 115–128, 1955; *Ref. Zh. Mekh.* 1956, Rev. 5312.

By a method suggested earlier by G. S. Salekhov for seams with water pressure conditions, the problem is solved by control of the petroleum-bearing contour in elastic conditions of the petroleum deposit for the case when the homogeneous seam of constant power has n operation crevices in the petroleum zone and 1 delivery crevice in the water zone. The initial position of the petroleum-bearing contour is a circumference of radius r_0, the final one is a circumference of radius r_1. The water zone extends to infinity, and the viscosity of the petroleum and of the water are considered equal. The law of contraction of the petroleum-bearing contour is selected in the form

$$r^2 = r_0^2 - \lambda(t)\,(r_0^2 - r_1^2)$$

in which $\lambda(t)$ is the current coefficient of development. The operational time T is divided into n parts. In each interval of time the discharges of the crevices are considered constant, the crevices being replaced by linear sources and outlets with an intensity constant over the length. Satisfying the mean equation in time of the motion of the petroleum-bearing contour and using the method of least squares, author obtains for each interval of time a system from which the discharges of the crevice are determined. The case of water pressure conditions is obtained by the limiting transition when the coefficient of piezo-conductivity is equal to infinity.

A detailed investigation is made of the case of two concentric operational batteries, and a numerical example is given.

V. A. Karpychev

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

1420. Krisonossov, I. V., and Charny, I. A., Calculation of the discharge from boreholes with fissuration of the adjacent stratum (in Russian), Neft. Kh-vo no. 9, 40–47, 1955; *Ref. Zh. Mekh.* no. 11, 1956, Rev. 7624.

Starting from simple hydraulic schematics, the limits are defined between which the values of the real discharge from a borehole are contained, for the case of fissuration of the stratum by the action of a hydraulic discontinuity. The cases of a vertical and a horizontal crack, respectively, are examined. It is suggested the discharge value for the calculation be assumed as half the sum of the highest and lowest values. As shown by the specimen calculations included in the work, the relative error in determining the discharge value for the case of a horizontal crack does not usually exceed 12–13%; and, for a vertical crack, 2%. Some qualititative conclusions are presented.

V. L. Danilov

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

1421. Nuzhin, M. T., Solution of a few problems on forced percolation (in Russian), *Inzhener. Sbornik. Akad. Nauk SSSR* **18,** 49–60, 1954.

Problems of flow through homogeneous materials with continuous uniform surface have been thoroughly investigated and solved in the past. Author solves problems of forced percolation in cases where the penetration through the surface is restricted in one or several levels, as occurs in foundation trenches, locks, etc. Part I presents solution by N. N. Pavlovskii; part II the method based on direct analysis of boundary conditions; part III demonstrates the solutions on several examples; and part IV discusses the solution by circulation of the flow. References are made to publications by P. J. Polubariniva-Kochina, M. A. Lavrentiev and B. B. Shabat, C. A. Cristianovich, C. G, Mihlin and B. B. Devison, E. A. Zamarin, N. T. Meleshenko, I. M. Ryzhik and I. S. Gradshtein, A. V. Romanov, A. Signorini.

J. J. Polivka, USA

Geophysics, Meteorology, Oceanography

(See also Revs. 1133, 1270)

1422. Estoque, M. A., A graphically integrable prediction model incorporating orographic influences, *J. Meteor.* **14,** 4, 293–296, Aug. 1957.

Two methods available for numerical forecasts of atmospheric circulation patterns are arithmetic (using digital computer) [Thompson, *Bull. Amer. meteor. Soc.* **38,** no. 8] and graphical [Fjortoft, *Tellus* **4,** p. 179]. E stoque [*J. Meteor.* **13,** p. 195] earlier applied graphical method to baroclinic model over level terrain and here includes topography in calculations. Orographically induced vertical velocity is introduced with a numerical maximum at the ground, and an analytic expression is prescribed for the vertical velocity profile. Vorticity is advected by a modified space mean wind field. Only one case of lee cyclonic development has been checked and that with apparently encouraging results.

R. C. Staley, USA

1423, Cohen, E., and Perrin, H., Design of multi-level guyed towers: wind loading, *Proc. Amer. Soc. civ. Engrs.* **83,** ST 5 (*J. Struct. Div.*), Pap. 1355, 30 pp., Sept. 1957.

In the analysis of multi-level guyed towers it is of decisive importance to establish the design wind loading exactly. Therefore, authors sum up for practical purposes the data necessary for the determination of the wind loading: the basic wind velocity, the gust factors, and the variation of these quantities with the height. They supply further the shape factors belonging to cylindrical bodies and plane trusses, the shielding effect of constructions put one behind the other, the wind forces of towers of square and of triangular cross section, the effects of forces attacking the guys, the ice-loading, etc. The different dynamic effects are

dealt with too, but reviewer believes that the Karman effect is not treated as exhaustively as would be desirable because of the importance of this question.

Paper is completed with plentiful references and a rich collection of figures useful for practical purposes.

P. Csonka, Hungary

1424. Scorer, R. S., Experiments on convection of isolated masses of buoyant fluid, *J. Fluid Mech* **2,** 6, 583–594, Aug. 1957.

Author proposes two simple laws for the behavior of isolated masses of buoyant fluid: (1) The diameter of the mass during buoyant ascent or descent is proportional to the vertical distance travelled from the place of origin. (2) The rate of vertical displacement is proportional to the buoyancy and to the horizontal area occupied by the mass. A considerable number of experiments in water in the laboratory support these relations and yield the proportionality constants. A few comparable observations from the atmosphere roughly yield the same constants. This leads author to conclude that the dynamical processes involved in convection in the atmosphere do not differ from those noted in the laboratory.

H. Riehl, USA

1425. Ellison, T. H., Turbulent transport of heat and momentum from an infinite rough plane, *J. Fluid Mech.* **2,** 5, 456–466, July 1957.

The dimensional laws of the eddy diffusivities of momentum and heat (i.e. density), K_M and K_H, in atmosphere are formulated in the first part. In the second part, using the "decay time" for the mean square density (i.e. temperature) fluctuation, for the turbulent energy and for the density flux, author derives a relation between K_M and K_H from the equations of the conservation of energy, momentum, and mass, together with some speculative assumptions.

Reviewer thinks this interesting paper would give some difficulties for engineers because of the absence of the description of the nomenclatures used by the meteorologists (and some misprints in the equations).

I. Sawai, Japan

1426. Inoue, E., Structure of turbulence in the atmospheric surface layer, Proc. sixth Japan nat. Congr. appl. Mech., Univ. of Kyoto, Japan, 315–318, 1956.

The detailed structure of velocity fluctuation in the atmospheric surface layer in three directions (fewer works have been done along this direction) has been discussed. Based on two sets of experiments, the passage period of coupling turbulon (turbulence element) in three dimensions (along-wind, cross-wind, and vertical) is shown to be nearly proportional to the characteristic time, called conveniently the equivalent passage-time. Naturally, these proportional constants may depend upon the thermal stratification and the roughness over the field, and theoretical derivation seems at present to be very difficult.

H. Arakawa, Japan

1427. Perkins, P. J., Lewis, W., and Mulholland, D. R., Statistical study of aircraft icing probabilities at the 700- and 500-millibar levels over ocean areas in the northern hemisphere, *NACA TN* 3984, 31 pp., May 1957.

A statistical study is made of icing data reported from weather reconnaissance aircraft flown by Air Weather Service (USAF). The weather missions studied were flown at fixed flight levels of 500 millibars (18,000 ft) and 700 millibars (10,000 ft) over wide areas of the Pacific, Atlantic, and Arctic Oceans. This report is presented as part of a program conducted by the NACA to obtain extensive icing statistics relevant to aircraft design and operation.

The thousands of in-flight observations recorded over a 2- to 4-year period provide reliable statistics on icing encounters for the specific areas, altitudes, and seasons included in the data. The relative frequencies of icing occurrence are presented, together with the estimated icing probabilities and the relation of these probabilities to the frequencies of flight in clouds and cloud temperatures.

The results show that aircraft operators can expect icing probabilities to vary widely throughout the year from near zero in the cold Arctic areas in winter up to 7% in areas where greater cloudiness and warmer temperatures prevail. The data also reveal a general tendency of colder cloud temperatures to reduce the probability of icing in equally cloudy conditions.

From authors' summary

1428. Hansen, C. F., The erosion of meteors and high-speed vehicles in the upper atmosphere, *NACA TN* 3962, 38 pp., Mar. 1957.

Analytic relations for velocity, deceleration, size, and relative magnitude of luminosity of meteors are derived in parametric form. Comparison of the theory with observed meteor behavior indicates that a large fraction of the atmospheric bombardment energy is used in eroding meteor material. Erosion from large, high-speed vehicles in free-molecule flow is calculated and the mass loss is found negligible.

From author's summary

1429. Gambo, K., Three-dimensional treatments of equations of motion without using the geostrophic approximations, *J. Meteor. Soc. Japan* **35,** 1, 1–11, Feb. 1957.

The problem of numerical forecasting involves numerical solution of five partial differential equations: three equations of motion, equation of continuity, and the energy equation. Complete solutions include sound waves and other meteorological "noise." Early methods of filtering "noise" used geostrophic approximation, but do not give approximations adequate for present-day numerical forecasting. Gambro introduces dimensionless G (ratio of streamfunction to velocity potential); also G (divergence/vorticity). Geostrophic flow is divergenceless, hence has $G = 0$. Gambro, from primitive equations, derives relations involving G explicitly. He suggests unimportant oscillations be eliminated not by $G = 0$ but by $|G| < 1$ so that terms in G^n $(n > 1)$ be neglected. Practical applications and techniques are not given or evaluated; they are to be presented by Gambro in *Pap. Meteor. Geophys.* **7,** 1.

R. C. Staley, USA

1430. Cadle, R. D., The chemistry and physics of the atmosphere, *SRI J.* **1,** 2, 52–58, 1957.

An orientative article on aerosols, solid and liquid, their occurrence and influence in the atmosphere. Purposes of aerosol research, preparation, properties and study of aerosols, nucleation of vapors, analysis of atmospheric contaminations, nuclear radiation, air currents, properties and exploration of the upper atmosphere by aircraft and rockets. Problems of radioactive fallout, air pollution abatement, weather modification, ice-fogs, upper air missiles, and satellite re-entry problems.

K. J. De Juhasz, Germany

1431. Kellogg, W. W., Diffusion of smoke in the stratosphere, *J. Meteor.* **13,** 3, 241–250, June 1956.

From theoretical analysis author determines growth of smoke puffs in upper atmosphere as funtion of time, height above ground and pertinent turbulence factors. Data from 18 smoke puffs are analyzed, showing that, from initial diameters of 18–20 m, diameters increased 5-fold in about three minutes. Comparison of theory and experiment suggests that root-mean-square eddy velocity in stratosphere is of order of 4–10 cm/sec and increases with height.

J. M. DallaValle, USA

Lubrication; Bearings; Wear

(See Rev. 1213)

Marine Engineering Problems

(See also Revs. 1126, 1269, 1272, 1324)

1432. Kimon, P. M., The planing characteristics of an inverted V prismatic surface with minus 10 degrees dead rise, *David W. Taylor Mod. Basin Rep.* 1076, 23 pp., Mar. 1957.

Report is one of a series on the experimental investigation of the planing characteristics of a series of related prismatic surfaces.

The principal planing characteristics have been obtained for an inverted V prismatic surface having an angle of dead rise of −10 deg. Wetted lengths, resistance, and center-of-pressure location were determined at speed coefficients ranging up to 19.5, beam-loading coefficients from 0.87 to 71.5, and trims up to 30 deg. Keel-wetted-length/beam ratios were extended to approximately 8.0 in all cases where excessive loads or excessive spray conditions were not encountered.

The data indicate that the important planing characteristics are independent of speed and load for a given trim and are dependent primarily upon lift coefficient. The difference between keel wetted length and chine wetted length is constant for a given trim angle. The ratio of center-of-pressure location forward of the trailing edge to the mean wetted length is dependent on trim angle and on wetted length. The drag data indicate that the friction-drag component is a large percentage of the total drag at the low trims but decreases rapidly with increase in trim. At the high trim angles of 24 and 30 deg, the induced drag exceeds the total drag and indicates an apparent negative friction force.

From author's summary

1433. Clement, E. P., and Kimon, P. M., Comparative resistance data for four planing boat designs, *David W. Taylor Mod. Basin Rep.* 1113, 20 pp., Jan. 1957.

Four existing models of planing craft were retested at the Taylor Model Basin's "standard condition" for planing boat models. The test results for each model are presented in a design data sheet. The data are compared to show the effects of differences in hull form. These comparisons are independent of differences in hull loading, in LCG location, or in size of boat. Auxiliary graphs are included to assist in making estimates of speed and power for new designs.

From authors' summary

1434. Isay, W. H., Voith-Schneider propeller in the wake of a ship body (in German), *Ing.-Arch.* **25,** 5, 303–318, July 1957.

Paper is a continuation of two earlier papers by the author in which he investigated the flow through the Voith-Schneider propeller itself, that is, without interaction with a ship hull. In the present work, two analyses are presented of the flow through the same propeller. The "simple" theory analyzes the interaction of flows around a circular cylinder and the propeller, and the "more exact" theory describes the flows around an idealized ship hull and the propeller. Both of these theories use appropriate source and sink distributions and point vortices to represent the flows. A correlation of the "simple" and the "more exact" theories shows that the simple theory gives good approximate results. Several numerical examples are worked and their results compared with those obtained in author's previous work.

T. P. Torda, USA

1435. van Manen, J. D., Recent research on propellers in nozzles, *J. Ship Res.* **1,** 2, 13–46, July 1957.

Paper presents to the designer of propellers for ship propulsion the results of systematic tests of propeller and nozzle combinations. This is the first presentation of such information in the twenty years since the introduction of the Kort nozzle.

In the tests, length-diameter ratio of the nozzle, the number of blades, and the blade-area ratio of the propeller have been varied. In addition, the results of experiments relative to the optimum diameter of the nozzle system behind the ship are described.

Curves and diagrams for nozzle design are included.

W. E. Hammond, England

Letters to the Editor

1436. Concerning AMR 10, Review 2905 (September 1957): Hemp, W. S., Stress analysis of multiweb boxes, Proc. Fifth International Conference, June 20–23, 1955, Los Angeles, Calif., 146–161; New York, Inst. of the Aeronautical Sciences, Inc.

Reviewer of the above was P. R. Hardesty and not R. M. Davies. The editors regret this error.

1437. Concerning AMR 10, Review 3351 (October 1957): Lindgren, E. R., The transition process and other phenomena in viscous flow, *Arkiv Fysik* 12, 1–169, Apr. 1957.

"Page 474 column 2 line 8–9 should run as follows: When R is between about 200 and 2000, flashes appear in the entrance flow but fade out. When R is between about 2000 and 2400 some flashes fade out and others maintain themselves without elongation or splitting into parts. When the Reynolds number is still higher, the flashes split or elongate and the resistance to the flow raises from what is called laminar to turbulent resistance."

H. Faxen, Sweden

1438. Concerning AMR 10, Review 3780 (November 1957): Larue, P., Optimal volume of gas container for the propulsion of liquid propelled rockets (in French), *Rech. aero.* no. 54, 17–20, Nov.-Dec. 1956.

Source was given as ONERA NT 54. The editors regret this error.

1439. Re: AMR 10, Review 3894 (December 1957): Peach, M. O., A modern course in engineering statics (Univ. Notre Dame, Canada), Montreal, Renouf Publishing Co., Ltd., 1956, viii + 31 Lessons.

Author informs us that copies may be obtained at $2.50, plus postage, by writing to M. O. Peach, Univ. of Notre Dame, Notre Dame, Indiana, U.S.A.

Books Received for Review

BARNA, P. S., Fluid mechanics for engineers, London, Butterworths Scientific Publications, 1957, x + 377 pp.

FISHER, J. C., Johnston, W. G., Thomson, R., and Vreeland, T., Jr., edited by, Dislocations and mechanical properties of crystals, An International Conference held at Lake Placid, September 6–8, 1956; New York, John Wiley & Sons, 1957, xiv + 634 pp. $15.00.

GRAVINA, P. B. J., Teoria e calculo das cascas, Sao Paulo, Brasil, Escola Politecnica de Sao Paulo, 1957, xii + 335 pp.

HUCKERT, J., Analytical kinematics of plane motion mechanisms, New York, Macmillan Co., 1958, vii + 209 pp. $7.75.

KLINKENBERG, A., and van der Minne, J. L., edited by, Electrostatics in the petroleum industry, New York, D. Van Nostrand Co., 1958, i + 191 pp. $8.00.

LANDAU, C., and Smorodinsky, Ya., Lectures on nuclear theory, New York, Consultants Bureau, Inc., 1958, 81 pp. $15.00.

MANTELL, C. L., edited by, Engineering materials handbook, New York, McGraw-Hill Book Co., Inc., 1958, xxxii + 1887 pp. $21.50.

Russian-English glossary of electronics and physics, New York, Consultants Bureau, Inc., 1957, ii + 343 pp. + app. $10.00. (Paperbound)

Russian-English glossary of nuclear physics and engineering, New York, Consultants Bureau, Inc., 1957, 195 pp. $10.00. (Paperbound)

Russian-English glossary of solid state physics, New York, Consultants Bureau, Inc., 1958, 90 pp. $10.00. (Paperbound)

STEINMAN, D. B., and Watson, Sara Ruth, Bridges and their builders, New York, Dover Publications, 1957, xvi + 401 pp. $1.95. (Paperbound)

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